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# Demand and Diversity of Use of Electricity on 16 Farms in the Eastern Livestock Area of Iowa

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CONTENTS

## SUMMARY

Sixteen farms in the eastern livestock area of Iowa were selected on basis of ownership of electric ranges and water heaters for a study of electrical demand. Records were obtained for a period of 1 year beginning April 1950. Each week four farms were metered with recording voltmeters and ammeters. Data for over-all farm demands were tabulated from the meter records for the highest 15-minute period of average demand in each hour. Many of the curves and factors were obtained by averaging values for demand which were not necessarily concurrent.

The farms in this study differed in many respects from those in the one conducted in 1947 by the Bureau of Agricultural Economics and the Iowa Agricultural Experiment Station. Most important of these differences was the average annual use of 7,225 kilowatt-hours for the farms in this study with water heaters but not ranges, as compared to an average of 3,081 kilowatt-hours for the farms in the other study.

The electrical demand of farms in this study varied with seasons of the year and ownership of ranges and/or water heaters. Variations in demand with days of the week were slight. The time of peak demand on Sundays differed from that on week days. There were peaks of demand between 6 and 8 a. m. and between 5 and 7 p. m. for all farms. Farms with ranges had relatively higher demand peaks than other farms and had peaks between 11 a. m. and noon. Use and demand were greater in the winter and early spring than in the summer and fall.

The diversity factors of the 16 farms varied from 1.4 in March 1951 to 1.9 in July 1950. The demand factors of the individual farms varied from 0.13 to 0.31. Load factors varied widely, both seasonally and among farms. Load factors for individual farms for a 1-week period were as high as 0.57 and as low as 0.02.

Operation of much of the electrical equipment used on the farms in this study could be identified from the ammeter records. Minutes of operation or, in the case of the range and ironer, average demand in amperes were tabulated by half-hour periods for selected appliances.

The seven welders in this study were used infrequently. They had an average use of about 85 minutes per year.

Grain elevators on farms in this study were used primarily for corn. The major part of their use in 1950 was confined to the period from Oct. 30 to Nov. 14. During periods of greatest use each elevator operated an average of 8.3 minutes.

The five milking machines in this study were used most often in the half-hour period preceding the morning and evening peaks. Their diversity factor based on half-hour demand periods was 1.7.

Fourteen of the 16 farm homes and 10 of the barnyards had water under pressure from pumps operated by electric motors. Peak use of manually controlled pumps occurred most often in the half-hour preceding the evening peak demand of the farms.

Electric heating units of stock waterers used large amounts of energy in winter. Their demand was heaviest at night.

Use of electric ranges was greatest between 7:30 and 8:30 a. m., 11 a. m. and noon, and 5:30 and 6:30 p. m. These peaks of use coincided with the peak demands of all 16 farms in practically all instances. The load factor for the 8 ranges over an 8-month period was 0.082. The diversity factor for this period was 2.55.

Time controls were used on three of the water heaters in this study. Much of the time one of the controls was improperly set, and the water heater operated at time of the farm peak.

Peak use of water heaters without time controls usually occurred slightly later than the peak use for the farms.

Demand of automatic washers for July, September, December and January was more diverse than the demand of nonautomatic washers for the same months, but Monday was the preferred day for washing with either type of washer. Highest demands of nonautomatic washers occurred between 9 a. m. and noon and were later in fall and winter than in summer.

Use of irons was well distributed over the days of the week. For the average of the four months considered, peaks of use occurred on Wednesday between 10 and 11 a. m. and between 8 and 8:30 p. m.

Voltage at the meter varied widely with loads and hours of the day. Electrical outages were few and of short duration.

Of the 2.97 percent average drop in voltage at the meter when a 1,000-watt resistance load was added to either of the 115-volt circuits, an average of 2.20 percent was found to be in the distribution transformer and connections.

Loads were not always balanced on each 115-volt circuit of a three-wire 115-230 volt service. The maximum difference was 13 in the simultaneous voltages between each of the two transformer windings and ground.

# Demand and Diversity of Use of Electricity on 16 Farms in the Eastern Livestock Area of Iowa[1]

By Landy B. Altman, Jr.,[2] Kathryn Philson,[3] and Ernest J. Buresh[4]

Use of electricity by farmers is increasing at a rapid rate. This increase in use is illustrated by the experience of the Marshall County Rural Electric Cooperative. In 1940 an average of 50 kw-hrs per month was used by its 227 consumers, in 1945 an average of 104 kw-hrs by 1,463 consumers, and in 1950 an average of 274 kw-hrs per month by 2,295 consumers. In February 1951 use jumped to an average of 406 kw-hrs per consumer.

While use of electricity is important, it is the demand which use creates that determines the design of farm wiring systems, transformers, distribution and transmission lines, and generation facilities. Many of the demand characteristics of present farm loads are not known. This lack of information has resulted in faulty distribution system design and inadequate electrical service to farmers.

Electric service which is free from interruptions and excessive voltage variations is particularly important on farms. Here many of the uses made of electricity are for production. Electric service which is not dependable or which supplies energy at a low voltage will interfere with the operation of milking machines, water pumps, refrigeration systems, brooders, and other equipment used in agricultural production. Farmers have expanded production so far with the help of electricity that without it they are unable to carry out their production programs.

## PURPOSE

This project was undertaken to furnish information on farm demand to suppliers of electricity to the end that electric

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service to farmers will be adequate to meet the increasing demand. Since it is difficult to obtain cooperators on a random basis in a study of this type and since cost limitations restricted the sample size, no effort was made to make the sample representative of the farms in the area, and area inferences should not be drawn from this study.

The program was planned to obtain data on the following specific items:

(1) Electrical energy demand of selected farms having various combinations of equipment,
(2) Correlation of demand with hours of the day, days of the week and seasons of the year,
(3) Electrical demand of specific equipment,
(4) Voltage variations on rural distribution systems with regard to time,
(5) Adequacy of secondary, service and farmstead wiring.

The eastern livestock area of Iowa was selected for this study so that it could be correlated with other work of the Iowa Agricultural Experiment Station which, in cooperation with the Bureau of Agricultural Economics, is studying the economic aspects of electrical use on farms in this area. A progress report of the economic phases of the study, U. S. Department of Agriculture Circular No. 852, "Electricity on Farms in the Eastern Livestock Area of Iowa," was published in September 1950.

## METHOD

Engineers of the Rural Electrification Administration suggested much of the basic plan for collecting and tabulating data used in this study. This plan was enlarged to provide more data on the electrical equipment causing the demand.

### SELECTION OF SAMPLE

To determine the influence of electric ranges and water heaters on demand, farms were selected on the basis of ownership of these appliances. Four farms were selected in each of the following groups:

Group I Electric range and electric water heater,
Group II Electric range,
Group III Electric water heater,
Group IV Neither electric range nor electric water heater.

One of the cooperators in group IV purchased a water heater shortly after the study was started. Thus, there were five farms in group III and three farms in group IV for much of the study.

As nearly as possible, the farms selected were drawn from the sample used in the previously mentioned study done cooperatively by the Iowa Agricultural Experiment Station and the Bureau of Agricultural Economics.

## INSTRUMENTATION

Graphic recording clock-driven A-C ammeters and voltmeters were used in securing data for this study. These instruments were selected because demand in volt-amperes could be derived from the records and because the operation of many individual appliances could be identified from the ammeter records.

Four of the 16 farms were metered at a time. Each week the meters were moved to different farms in sequence. Each farm was metered for 1 week of each 4 for a year. For part of the year the eight ranges and eight houses were metered concurrently with the entire farm. Special ammeter records were obtained for the operation of many appliances. These records were used primarily to assist in identifying the operation of individual appliances when the total current requirements of the home or farm were on a single ammeter record.

A typical meter arrangement at the yardpole of one of the cooperating farms is shown in fig. 1. The meters were housed in a plywood instrument shelter chained to the pole. Adapters that plugged into meter sockets were made for the leads to the current transformers. The service watt-hour meter usually plugged into the adapter. If watt-hour meters which did not plug into a socket were used, as in fig. 1, a meter socket was wired into the meter loop to accommodate the adapter.

Provisions were made to meter house and range circuits by breaking the wiring with range outlets and plugs which permitted placing the current transformers in series with the range or house loads. Circuits were reconnected after each metering period. In two homes ranges were metered from the range outlet in the kitchen.

A wiring analyzer containing a 115-volt 1000-watt load which could be placed in the electrical circuit and a voltmeter calibrated both in volts and in percent voltage drop was used to measure the voltage and voltage drops at various locations on the farms.

Readings from service watt-hour meters were obtained for the periods metered. The power suppliers furnished the amount of electrical energy each cooperator used each month.

## INFORMATION SCHEDULES

An information schedule was prepared for each cooperator. The schedule included the nameplate data of electrical equip-

Fig. 1. Metering equipment at yardpole.

ment owned, appliances added or discontinued while the study was in progress, monthly energy consumptions, energy consumption for metered periods, voltage drops from the transformer to various buildings and loads, diagrams of exterior wiring and miscellaneous information.

## COMPARISON OF THE 16 FARMS STUDIED WITH ALL FARMS IN THE EASTERN LIVESTOCK AREA

Comparisons have been made between the distribution of the 16 farms and an estimate for all farms in the area in respect to energy consumption, years electrified, income, size, livestock enterprises and tenure status. Estimates pertaining to all farms in the area were made from a statistically reliable sample of 461 farms surveyed in the spring of 1948. Ten of the 16 farms were included in this survey, and comparable information was obtained on the other six so that all comparisons could be made for 1947.

The 16 farms differed markedly in 1947 from the distribution of all farms in the area with respect to ownership of ranges and water heaters and in electrical energy consumption as indicated in table 1.

Comparisons between the groups of farms studied and all farms in the area are given in figs. 2 through 8. The table at the right of the graph in each figure indicates the distribution within each of the four groups of farms. One of the cooperators in group III was not farming in 1947 so this farm was omitted from comparison of income and kilowatt-hour consumption.

TABLE 1. COMPARISON OF THE KILOWATT-HOUR CONSUMPTION OF 461 FARMS IN THE EASTERN LIVESTOCK AREA OF IOWA WITH THE 16 FARMS STUDIED.

| Group | Farms in eastern livestock area, 1947 | | Sixteen farms* | |
|---|---|---|---|---|
| | Distribution percent | Average per year kw-hr. | Average per year, 1947 kw-hr. | Average per year, 1950 kw-hr. |
| I Range, water heater | 12 | 4,653 | 4,241 | 9,781 |
| II Range | 15 | 2,762 | 3,352 | 4,214 |
| III Water heater | 11 | 3,081 | 7,225 | 10,447 |
| IV No range or water heater | 62 | 1,425 | 1,992 | 2,967 |

*The farm with the lowest kw-hr consumption in group I purchased a water heater after 1947. The consumption of this appliance does not enter into the 1947 average of 4,241 kw-hrs for this group.

Following is a summary of the comparisons:

(1) KILOWATT-HOUR CONSUMPTION

The average annual kilowatt-hour consumption of the 16 case-study farms was more than double the estimate for the average of all farms in the area. While the amount of energy used on the farms studied varied considerably, the variation was less than for all farms in the area. None of the farms in the group was among the lowest consumers in the area while 2 of the 16 were among the high energy users.

There appear to be important differences among the four groups of farms in the energy used. The four farms with water heaters only used a much greater amount of energy than any of the other three groups. However, when all farms in the area were considered, it was the range and water heater group which used the most kilowatt-hours. The differences in energy consumption among the four groups for all farms in the area can be attributed to the ownership of a range and/or water heater. This was not true among the 4 groups in the 16-farm "sample" studied. This divergence suggests important differences in the uses made of electricity for purposes other than heating water for the household between the farms in this study with water heaters and all farms in the area which fall within this category.

(2) YEARS ELECTRIFIED

Most of the 16 farms were electrified earlier than were most farms in the area. Half of these farms had high-line electric service before 1939 as compared with only 27 percent of all farms in the area.

(3) INCOME

Few of the farms studied were among the low income farms

| KW-HRS 1947 | PERCENT OF FARMS, EASTERN LIVESTOCK AREA | 16 FARMS | | | | |
|---|---|---|---|---|---|---|
| | | TOTAL (NO.) | FARMS IN GROUP | | | |
| | | | I | II | III | IV |
| | 10 20 30 | | | | | |
| UNDER 1000 | | 0 | - | - | - | - |
| 1000-1999 | | 4 | 1 | 1 | - | 2 |
| 2000-2999 | | 3 | 1 | 1 | - | 1 |
| 3000-3999 | | 2 | - | - | 2 | - |
| 4000-4999 | | 3 | 1 | 2 | - | - |
| 5000-5999 | | 1 | - | - | 1 | - |
| 6000-6999 | | 0 | - | - | - | - |
| 7000-7999 | | 0 | - | - | - | - |
| 8000-OVER | | 2 | 1 | - | 1 | - |
| AVERAGE | 2174 | 4350 | 4241 | 3352 | 7225 | 1992 |
| MEDIAN | 1375 | 3801 | | | | |

Fig. 2. Kilowatt-hour consumption of 461 farms in Eastern Livestock Area of Iowa and 16 case-study farms, 1947.

| YEAR | PERCENT OF FARMS, EASTERN LIVESTOCK AREA (0 10 20 30) | 16 FARMS TOTAL (NO.) | FARMS IN GROUP I | II | III | IV |
|---|---|---|---|---|---|---|
| BEFORE 1937 | | 5 | 2 | 1 | 2 | - |
| 1937-1938 | | 3 | - | 1 | 1 | 1 |
| 1939-1940 | | 6 | 1 | 2 | 1 | 2 |
| 1941-1942 | | 2 | 1 | - | 1 | - |
| 1943-1944 | | 0 | - | - | - | - |
| 1945-1946 | | 0 | - | - | - | - |

Fig. 3. Year electrified, 461 farms in Eastern Livestock Area of Iowa and 16 case-study farms, 1947.

| INCOME (DOLLARS) | PERCENT OF FARMS, EASTERN LIVESTOCK AREA (0 10 20 30) | 16 FARMS TOTAL (NO.) | FARMS IN GROUP I | II | III | IV |
|---|---|---|---|---|---|---|
| UNDER 4000 | | - | - | - | - | - |
| 4000-5999 | | 1 | - | - | - | 1 |
| 6000-9999 | | 4 | 1 | 1 | 1 | 1 |
| 10,000-14,999 | | 3 | 1 | 1 | 1 | |
| 15,000-19,999 | | 4 | 2 | 1 | 1 | |
| 20,000-OVER | | 3 | - | 1 | 1 | 1 |

Fig. 4. Income of farm families, 461 farms in Eastern Livestock Area of Iowa and 16 case-study farms, 1947.

| ACRES | PERCENT OF FARMS, EASTERN LIVESTOCK AREA (0 10 20 30) | 16 FARMS TOTAL (NO) | FARMS IN GROUP I | II | III | IV |
|---|---|---|---|---|---|---|
| UNDER 70 | | 0 | - | - | - | - |
| 70-139 | | 1 | - | - | 1 | - |
| 140-179 | | 4 | 2 | 1 | 1 | - |
| 180-219 | | 5 | 1 | 2 | 1 | 1 |
| 220-259 | | 2 | - | 1 | - | 1 |
| 260-OVER | | 4 | 1 | - | 2 | 1 |
| AVERAGE | 165 ACRES | 219 | 200 | 201 | 222 | 295 |

Fig. 5. Size of farm, 461 farms in Eastern Livestock Area of Iowa and 16 case-study farms, 1947.

| ANIMAL UNITS | PERCENT OF FARMS, EASTERN LIVESTOCK AREA (0 10 20 30) | 16 FARMS TOTAL (NO.) | FARMS IN GROUP I | II | III | IV |
|---|---|---|---|---|---|---|
| 0-24 | | 1 | - | 1 | - | - |
| 25-49 | | 6 | 1 | 1 | 1 | 3 |
| 50-74 | | 6 | 2 | 2 | 2 | - |
| 75-99 | | 2 | 1 | - | 1 | - |
| 100-124 | | 0 | - | - | - | - |
| 125-149 | | 0 | - | - | - | - |
| 150-OVER | | 1 | - | - | 1 | - |
| AVERAGE | 41 | 60 | 55 | 55 | 94 | 34 |

Fig. 6. Animal units, 461 farms in Eastern Livestock Area of Iowa and 16 case-study farms, 1947.

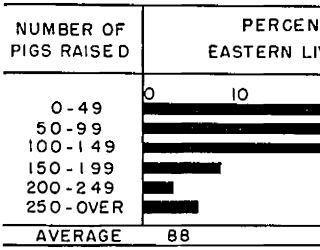
in the area. Only 1 of the 16 (6 percent) reported a gross income of less than $6,000, while approximately 30 percent of all farms had lower incomes. Seven of the 16 farms (44 percent) had incomes exceeding $15,000 as compared to 30 percent of all farms.

(4) SIZE OF FARM

The average size of the 16 farms studied was 219 acres as compared with an estimated 165 acres for all farms in the area. Five of the 16 farms (31 percent) contained less than 180 acres, while about 64 percent of the farms in the area were of that size. No farms of less than 70 acres were included in the group studied although about 16 percent of all farms in the area were smaller than this.

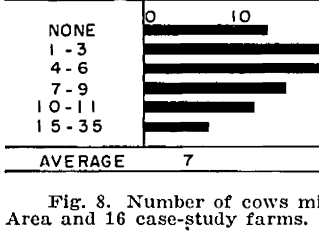
(5) LIVESTOCK ENTERPRISES

As measured by animal units, the 16 farms do not appear to be strikingly different from farms in the whole area. However, hog production is on a larger scale. Five farms in the group studied (31 percent) raised 250 pigs or more a year while only about 6 percent of all farms in the area carried on a hog program of this size. The average number of cows




| 16 FARMS | | | | |
|---|---|---|---|---|
| TOTAL FARMS IN GROUP | | | | |
| (NUMBER) | I | II | III | IV |
| 4 | - | 2 | - | 2 |
| 0 | - | - | - | - |
| 5 | 2 | 1 | 2 | - |
| 1 | - | - | 1 | - |
| 1 | - | - | - | - |
| 5 | 2 | 1 | 2 | - |
| 14 8 | | | | |

Fig. 7. Number of pigs raised in 1947, 461 farms in Eastern Livestock Area of Iowa and 16 case-study farms.




| 16 FARMS | | | | |
|---|---|---|---|---|
| TOTAL FARMS IN GROUP | | | | |
| (NUMBER) | I | II | III | IV |
| 1 | - | 1 | - | - |
| 4 | 2 | - | 1 | 1 |
| 6 | 1 | 2 | 2 | 1 |
| 1 | - | 1 | - | - |
| 2 | 1 | - | 1 | - |
| 2 | - | - | 1 | 1 |
| 7 | 5 | 5 | 8 | 13 |

Fig. 8. Number of cows milked in 1947, 461 farms in Eastern Livestock Area and 16 case-study farms.

milked per farm and the distribution of farms by the number of cows milked are about the same for the 16 farms as for all farms in the area.

(6) TENURE STATUS

No difference was found in tenure status between this group of farms and all farms in the area. Six of the 16 operators (38 percent) were renters as compared with the same percent for the area.

## ELECTRICAL DEMAND CHARACTERISTICS OF FARMS

The various aspects of the electrical demand of the farms in this study are shown by means of daily and weekly demand curves and by tables showing diversity, demand and load factors.

The individual demands used in preparing average demand curves should be obtained coincidentally and be for exactly the same time intervals. Some of the data used in this study were not so obtained for the following reasons: (1) Data were usually totaled by hours for periods of 1 week. Only the highest 15-minute period of averaged demand in each hour was tabulated. Since the highest 15-minute period of averaged demand occurred anytime during the hour, the values of demand for the various farms for a given hour may not have been in the same 15-minute period. (2) Meter records of only 4 of the 16 farms could be obtained at one time. In totaling the demand of groups of farms and of the 16 farms, all weeks of each month were considered as being alike.

Curves and factors which required the use of such data were only approximations of those which might have resulted from coincident demand. Since the problems of coincidence did not enter into the calculations of load factors and demand factors of individual farms, the accuracy of these was not influenced by this problem.

### VARIATION IN DEMAND BETWEEN GROUPS

The electrical demand of the farms in this study by groups is shown in figs. 9 to 12. These curves were prepared by averaging the highest 15-minute periods of demand for each hour for each group for a period of 1 week. These curves show the demands of the four groups of farms by hours of the day and days of the week for the months of July, September and December, 1950, and March 1951. Four farms were in groups I and II for all months; five farms were in group III except in March when there were four; and three farms were in group IV except in March when there were two.

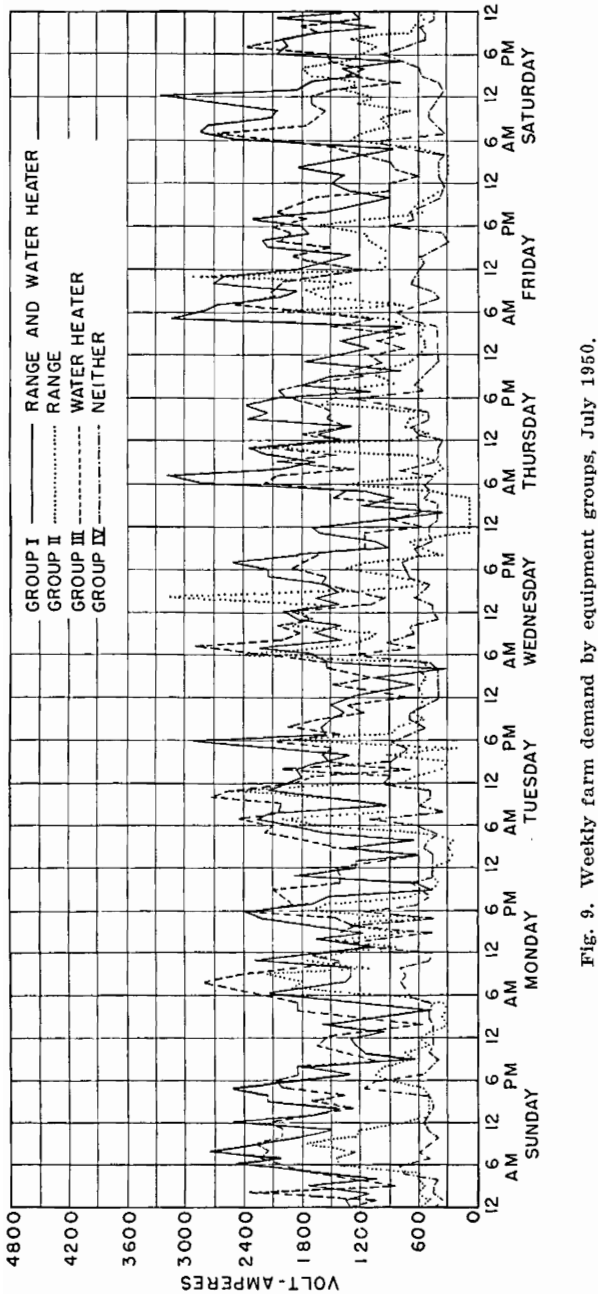



Fig. 9. Weekly farm demand by equipment groups, July 1950.

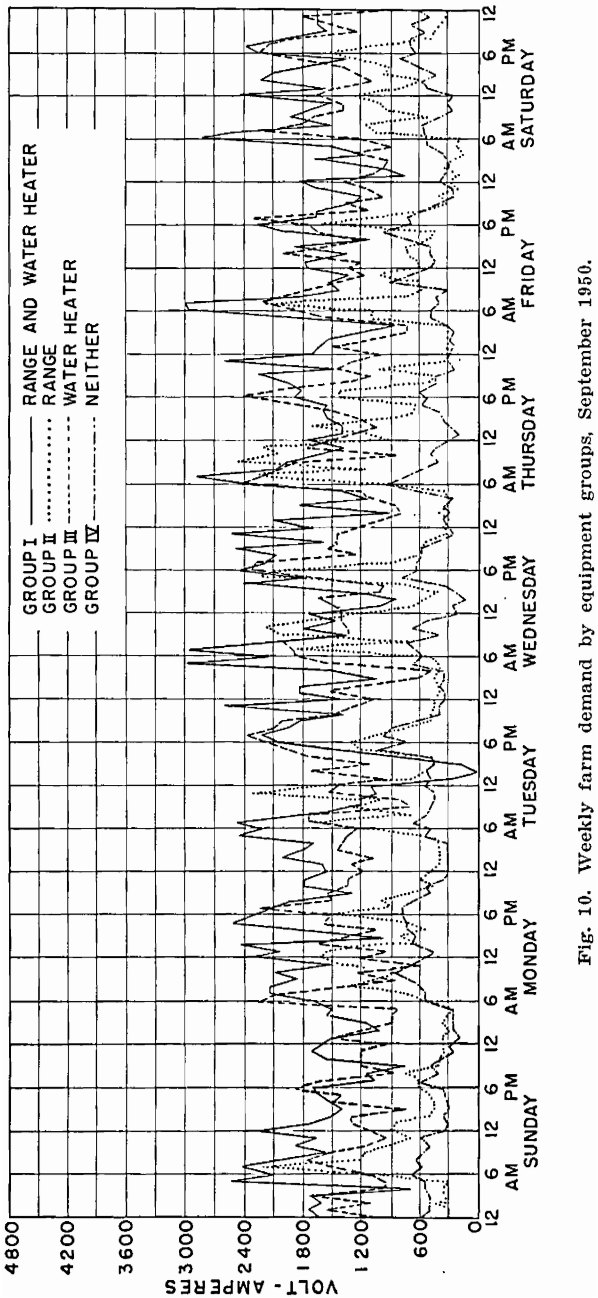



Fig. 10. Weekly farm demand by equipment groups, September 1950.

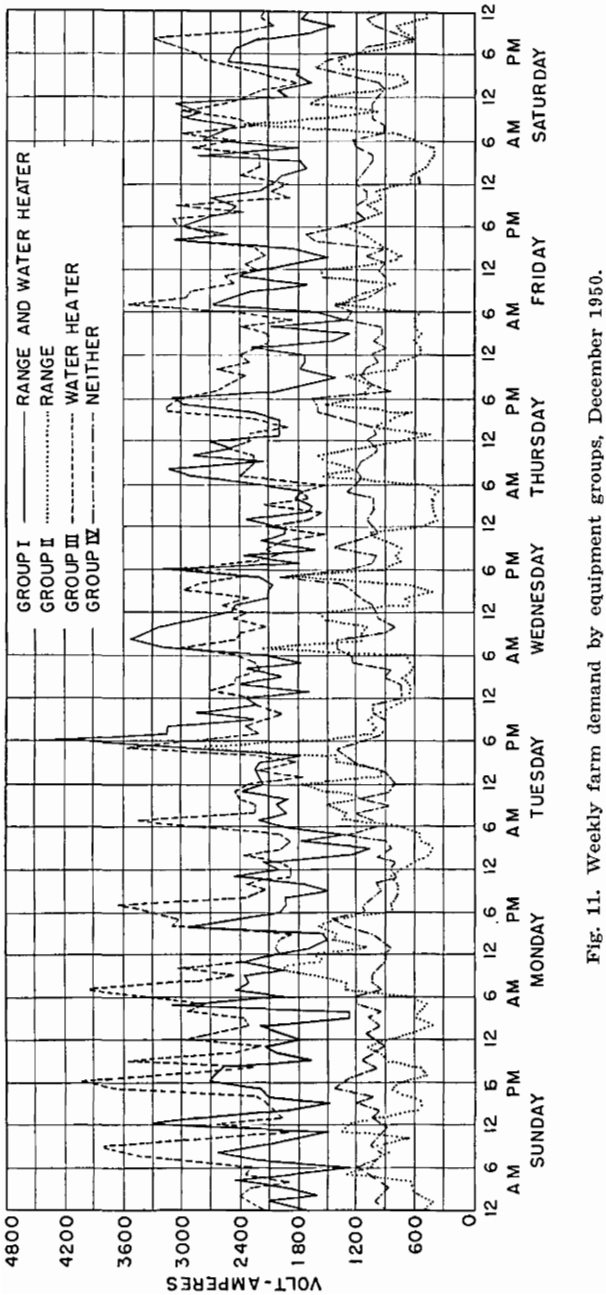



Fig. 11. Weekly farm demand by equipment groups, December 1950.

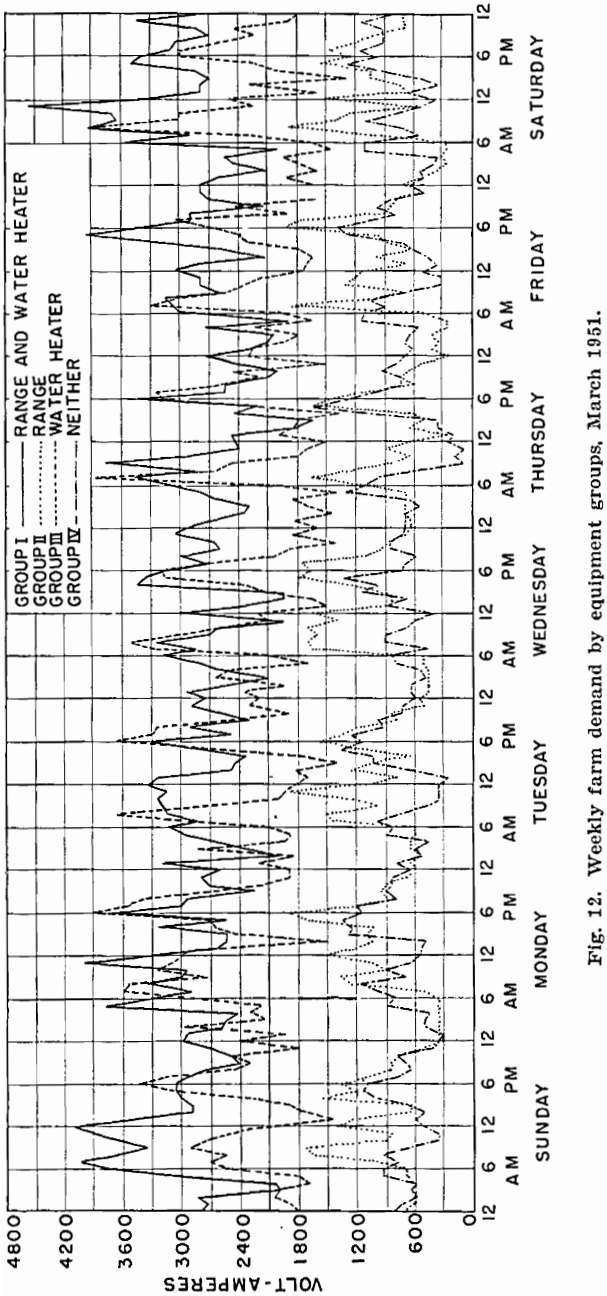



Fig. 12. Weekly farm demand by equipment groups, March 1951.

Marked differences may be noted in the average heights of the demand curves of the groups of farms. Since there is a correlation between connected load and demand, part of these differences may be explained by the variations in the average connected loads of the groups of farms. The average connected loads of the farms for groups I through IV were 38, 25, 42 and 21 kilowatts respectively.

The group of farms with water heaters only had higher connected load and energy consumption than the group with both ranges and water heaters. A random sample of 450 farms in this area in 1947 showed no correlation between ownership of ranges and water heaters and annual energy consumption, apart from that used by the above appliances.[5] These data are shown in table 2. The small number of farms and the method of sample selection used in this study resulted in the average connected loads that were not representative of all farms in the area.

TABLE 2. AVERAGE ANNUAL ENERGY CONSUMPTION OF 450 FARMS HAVING DIFFERENT COMBINATIONS OF OWNERSHIP OF ELECTRIC RANGE AND WATER HEATER, 1947.

| Group | Average annual consumption kw–hr | Average annual consumption less average energy requirements of range and water heater* kw–hr | Farms, number |
|---|---|---|---|
| Range, water heater | 4,653 | 1,453 | 54 |
| Range | 2,762 | 1,562 | 66 |
| Water heater | 3,081 | 1,081 | 48 |
| No range or water heater | 1,425 | 1,425 | 282 |

*Values for average energy requirements obtained from U. S. Department of Agriculture Circular 852, p. 88, September 1950.

## SEASONAL VARIATIONS IN DEMAND

Groups I and III had a greater concentration of farm appliances as chick and pig brooders, electrically heated stock waterers, dairy water heaters, welders and grain elevators than the other groups. Use of many of these appliances is heaviest in the winter and early spring. The curves in figs. 9 through 12 show that the demand of all groups was relatively low in July and that the demand of groups I and III increased more in December and March than the other groups.

Seasonal variations in peak demand are more clearly shown in fig. 13 than in figs. 9 to 12. The points for the curves in fig. 13 were taken from figs. 9 to 12 and represent the maximum 15-minute period of average demand for each day.

[5] Woodworth, Roger. Unpublished data obtained by Agricultural Economics Department of Iowa Agricultural Experiment Station.

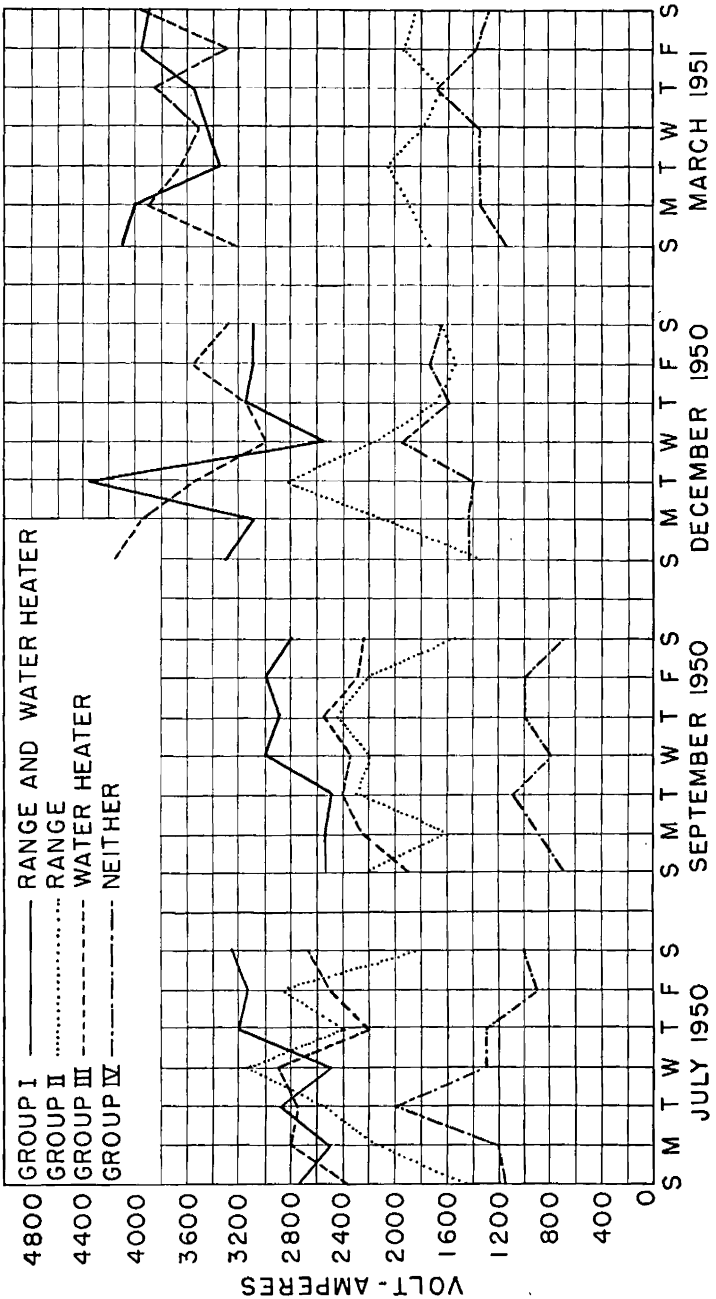



Fig. 13. Daily peak demand of equipment groups.

## VARIATIONS IN DEMAND BY HOURS OF THE DAY

Demand varies widely with hours of the day. All groups of farms show decided peaks of electrical use in the mornings and in the evenings; those with ranges show an additional midday peak. The morning peak period of demand occurred at about the same time for each of the groups of farms. In July an equal number of peak demand periods occurred between 6 and 7 a. m. and between 7 and 8 a. m. In September, December and March most of the morning peaks occurred between 7 and 8 a. m.

The time of the evening peak varied more widely than the time of the morning peak. The evening peaks for groups I, II and III occurred most often between 6 and 7 p. m. in July and September. An equal number of peaks occurred between 5 and 6 and between 6 and 7 p. m. in December and March for these groups. The evening peak demand of group IV occurred most often between 6 and 7 p. m. in July and between 5 and 6 p. m. for September, December and March.

The midday peak was about the same height as the morning and evening peaks for groups I and II. It usually occurred between 11 a. m. and noon, but it often occurred between 12 and 1 p. m., particularly in group I. There was a slight peak for group III occurring any time between noon and 3 p. m. The farms in group IV did not show a peak demand in the middle of the day.

The demand of the morning and evening peaks for any one group was usually about the same; however, the maximum peaks occurred most often in the mornings in July and September and in the evenings in December and March.

## VARIATIONS IN DEMAND BY DAYS OF THE WEEK

The farms studied showed little variation in demand among days of the week. The morning peak demand occurred about an hour later on Sunday than for the rest of the week for the farms in groups I, II and III. The morning peak demand of group IV occurred as early on Sunday as on any other day.

It was expected that greater use of washing machines and resultant use of hot water would cause the demand of groups I and III, farms having electric water heaters, to be higher on Mondays than on other days. However, increased use of these appliances did not cause noticeable differences in farm demands between Mondays and other days.

## MAXIMUM DEMAND FOR PERIODS OF 1 MINUTE OR LONGER

Maximum demand for periods of 1 minute or longer for each hour and the time and duration of the demand were tabu-

lated from the meter records. Motor starting-current demands and the current used by welders were omitted from these tabulations. The maximum demand of 1 minute or longer for each farm is presented by months in table 3.

The demand of 11.1 kilovolt-amperes for farm 1-1 was the highest recorded in this study. This demand occurred at 11:39 p. m., December 31, 1950. The highest 15-minute period of average demand between 11 and 12 p. m. on this day was 9.9 kilovolt-amperes. A 16,300-watt double-oven range caused most of this demand. Voltage at the yardpole meter dropped to 192/96 at this time. .

All farms in this study were served with 3-kva transformers except farm 4-3, which had a 7½-kva transformer.

## DIVERSITY FACTORS

Diversity factor is the ratio of the sum of the individual maximum demands of the various parts of a system to the maximum simultaneous demand of the whole system. Each group of farms and all the farms in this study were considered as separate systems. Diversity factors for them are shown in table 4.

The maximum 15-minute period of integrated demand for each month for each farm was used to obtain the sum of the individual maximum demands. The maximum simultaneous demand of each group of farms was obtained by adding the highest 15-minute demands in each hour by hours of the week and selecting the highest total. Since these 15-minute periods did not necessarily fall at the same time within each hour, the maximum demands of the system are probably higher and the calculated diversity factors correspondingly lower than they would have been had they been calculated from coincident system maximum demands.

Diversity factors were calculated for July, September and December 1950, and March 1951. The maximum 15-minute periods of integrated demand for each farm in each month are presented in this table so that they may be compared with the highest 1-minute demand peaks shown in table 3.

## DEMAND FACTORS

Demand factor is the ratio of the maximum demand to the total connected load of the system. The demand factors of the farms in this study are shown in table 5.

Since currents used by welders were not considered in tabulating the demand from the meter records, welders were excluded from the connected load in calculating the demand factors. The appliances owned by each cooperator are listed in the Appendix.

TABLE 3. HIGHEST DEMAND OF 1 MINUTE OR LONGER FOR 16 FARMS, 1950–51.

| Farm No. | Kilovolt–Amperes | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
| Group I —Range and water heater | | | | | | | | | | | | |
| 1–1 | — | 7.0 | 9.4 | 7.8 | 10.0 | 7.2 | 10.4 | 8.5 | 11.1 | 9.3 | 7.2 | 7.0 |
| 7–1 | — | 6.6 | 6.4 | 7.4 | 6.2 | 5.4 | 8.6 | 5.6 | 5.8 | 7.2 | 6.9 | 9.5 |
| 8–1 | — | — | 7.1 | 7.6 | — | 6.0 | 6.6 | 6.3 | 6.2 | 7.9 | 7.3 | 9.1 |
| 16–1 | — | — | 5.7 | 5.1 | 5.3 | 6.3 | 6.4 | 7.1 | 5.7 | 6.1 | 4.4 | 5.5 |
| Group II —Range | | | | | | | | | | | | |
| 3–2 | 6.0 | — | — | 5.1 | 5.2 | 5.4 | 5.6 | 8.0 | 6.7 | 5.9 | 6.0 | 5.7 |
| 9–2 | 5.8 | — | — | 5.9 | 6.8 | 5.4 | 6.7 | 5.5 | 6.4 | 5.7 | 5.5 | 6.5 |
| 11–2 | 6.1 | — | 5.1 | 4.2 | 6.3 | 3.7 | 4.0 | 3.9 | 5.3 | — | 5.2 | 4.4 |
| 13–2 | — | 3.2 | 4.1 | 4.3 | 5.3 | — | 4.1 | 3.2 | 3.6 | — | 2.9 | 4.1 |
| Group III—Water heater | | | | | | | | | | | | |
| 2–3 | — | — | — | 4.8 | 5.3 | 4.6 | 4.9 | 5.7 | 5.3 | 5.7 | 5.6 | — |
| 4–3 | 6.6 | 5.1 | — | 10.0 | 7.3 | 8.0 | 6.7 | 8.0 | 7.9 | 8.2 | 9.4 | 6.2 |
| 12–4 | 2.9 | 2.4 | 3.3 | 3.1 | 2.8 | 2.9 | 2.5 | — | 4.0 | 4.3 | 4.7 | 4.8 |
| 14–3 | 3.6 | — | 5.3 | 5.0 | 3.8 | 5.9 | 7.0 | 4.6 | 4.9 | 5.0 | 3.7 | 3.6 |
| 15–3 | — | 5.1 | 4.4 | 4.7 | 4.4 | 4.1 | 4.2 | 4.4 | 7.4 | 5.0 | 5.5 | 5.9 |
| Group IV—No range or water heater | | | | | | | | | | | | |
| 5–4 | — | — | 3.2 | 4.7 | 4.9 | 4.4 | 4.4 | 4.9 | 3.0 | 2.6 | — | — |
| 6–4 | — | 1.9 | 1.9 | 1.9 | 2.3 | 1.8 | 2.3 | 2.5 | 2.5 | 3.1 | 2.5 | 2.6 |
| 10–4 | 1.9 | 1.6 | 2.2 | 1.6 | — | 1.6 | 2.1 | 1.9 | 2.2 | 2.5 | — | 2.3 |

TABLE 4. HIGHEST MONTHLY 15-MINUTE PERIOD OF AVERAGED DEMAND IN KILOVOLT-AMPERES OF FARMS AND DIVERSITY FACTORS OF GROUPS OF FARMS, 1950–51.

| Farm No. | Kilovolt-Amperes | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
| Group I —Range and water heater | | | | | | | | | | | | |
| 1–1 | — | 4.7 | 7.0 | 5.6 | 7.1 | 4.5 | 8.8 | 6.9 | 9.9 | 6.8 | 7.2 | 5.4 |
| 7–1 | — | 5.1 | 4.4 | 5.8 | 4.4 | 4.3 | 5.6 | 4.4 | 4.6 | 5.1 | 5.4 | 8.4 |
| 8–1 | — | — | 5.6 | 4.6 | — | 4.7 | 4.8 | 4.4 | 5.1 | 5.9 | 5.6 | 7.8 |
| 16–1 | — | — | 4.0 | 4.4 | 3.6 | 4.2 | 5.3 | 5.3 | 4.8 | 4.1 | 3.6 | 3.6 |
| Total | — | 9.8 | 21.0 | 20.4 | 15.1 | 17.7 | 24.5 | 21.0 | 24.4 | 21.9 | 21.8 | 25.2 |
| Max. simultaneous demand | | | | 13.0 | | 12.0 | | | 13.3 | | | 18.7 |
| Diversity factor | | | | 1.6 | | 1.5 | | | 1.8 | | | 1.3 |
| Group II —Range | | | | | | | | | | | | |
| 3–2 | 4.2 | — | — | 3.8 | 4.0 | 4.1 | 4.2 | 5.2 | 4.3 | 4.9 | 4.4 | 4.2 |
| 9–2 | 5.1 | — | — | 5.0 | 5.2 | 4.1 | 5.8 | 4.6 | 4.8 | 4.1 | 4.7 | 4.1 |
| 11–2 | 4.5 | — | 2.7 | 3.1 | 3.6 | 2.9 | 2.8 | 3.0 | 3.7 | — | 4.4 | 2.9 |
| 13–2 | — | 2.5 | 2.8 | 3.6 | 4.4 | — | 3.5 | 2.6 | 2.4 | — | 1.3 | 3.1 |
| Total | 13.8 | 2.5 | 5.5 | 15.5 | 17.2 | 11.1 | 16.3 | 15.4 | 15.2 | 9.0 | 14.8 | 14.3 |
| Max. simultaneous demand | | | | 11.5 | | 7.8 | | | 11.4 | | | 8.2 |
| Diversity factor | | | | 1.3 | | 1.4 | | | 1.3 | | | 1.7 |
| Group III—Water heater | | | | | | | | | | | | |
| 2–3 | — | — | — | 3.8 | 3.3 | 3.6 | 4.0 | 4.5 | 4.4 | 5.3 | 4.9 | — |
| 4–3 | 5.8 | — | — | 5.8 | 5.4 | 5.1 | 5.4 | 6.0 | 7.2 | 7.3 | 7.9 | 5.5 |
| 12–4 | 2.3 | 1.7 | 3.3 | 2.6 | 1.9 | 1.8 | 1.5 | — | 3.4 | 3.4 | 3.8 | 4.3 |
| 14–3 | 3.2 | — | 3.8 | 3.2 | 3.5 | 4.8 | 5.6 | 4.0 | 4.3 | 4.3 | 3.2 | 3.3 |
| 15–3 | — | 4.9 | 4.0 | 4.0 | 3.7 | 3.9 | 3.5 | 3.8 | 6.3 | 3.2 | 5.4 | 5.9 |
| Total | 11.3 | 6.6 | 11.1 | 19.4 | 17.8 | 19.2 | 20.0 | 18.3 | 25.6 | 23.5 | 25.2 | 19.0 |
| Max. simultaneous demand | | | | 12.4 | | 12.8 | | | 19.7 | | | 15.6 |
| Diversity factor | | | | 1.6 | | 1.5 | | | 1.3 | | | 1.2 |
| Group IV—No range or water heater | | | | | | | | | | | | |
| 5–4 | — | — | 2.7 | 2.1 | 2.3 | 1.6 | 2.9 | 3.6 | 2.6 | 2.2 | — | — |
| 6–4 | — | 1.7 | 1.8 | 1.7 | 2.1 | 1.7 | 2.0 | 2.1 | 2.2 | 2.4 | 2.1 | 2.3 |
| 10–4 | 1.5 | 1.5 | 2.0 | 1.5 | — | 1.5 | 2.1 | 1.6 | 1.4 | 1.3 | — | 1.5 |
| Total | 1.5 | 3.2 | 6.5 | 5.3 | 4.4 | 4.8 | 7.0 | 7.3 | 6.2 | 5.9 | 2.1 | 3.8 |
| Max. simultaneous demand | | | | 3.8 | | 3.1 | | | 4.9 | | | 3.4 |
| Diversity factor | | | | 1.4 | | 1.5 | | | 1.3 | | | 1.1 |
| All farms total | | | | 60.6 | | 52.8 | | | 71.4 | | | 62.3 |
| Max. simultaneous demand | | | | 32.1 | | 34.7 | | | 38.8 | | | 44.3 |
| Diversity factor | | | | 1.9 | | 1.5 | | | 1.8 | | | 1.4 |

TABLE 5. DEMAND FACTORS OF INDIVIDUAL FARMS.

| Farm and group | Connected load | | Maximum demand kva | Demand factor |
|---|---|---|---|---|
| | Total load kw | Load less welder kw | | |
| Group I—Range and water heater | | | | |
| 1–1 | 34 | 34 | 9.9 | .29 |
| 7–1 | 37 | 31 | 8.4 | .27 |
| 8–1 | 35 | 35 | 7.8 | .22 |
| 16–1 | 47 | 37 | 5.3 | .14 |
| Group II—Range | | | | |
| 3–2 | 38 | 30 | 5.2 | .17 |
| 9–2 | 23 | 23 | 5.8 | .25 |
| 11–2 | 21 | 21 | 4.5 | .21 |
| 13–2 | 17 | 17 | 4.4 | .26 |
| Group III—Water heater | | | | |
| 2–3 | 31 | 24 | 5.3 | .22 |
| 4–3 | 60 | 50 | 7.9 | .16 |
| 12–4 | 14 | 14 | 4.3 | .31 |
| 14–3 | 36 | 31 | 5.6 | .18 |
| 15–3 | 25 | 25 | 6.3 | .25 |
| Group IV—No range or water heater | | | | |
| 5–4 | 36 | 27 | 3.6 | .13 |
| 6–4 | 17 | 17 | 2.4 | .14 |
| 10–4 | 10 | 10 | 2.1 | .21 |

The connected loads are in kilowatts, and the maximum demands are in kilovolt-amperes and represent the highest average 15-minute period of demand that occurred at any time during the year while the farm was being metered. The errors in the demand factors in table 5 resulting from dividing kilovolt-amperes by kilowatts are small, particularly if the power factor approaches unity. When the power factor of the maximum demand is 0.80, the range of error is from minus 0.02 for the smaller demand factors to minus 0.06 for the larger ones.

## LOAD FACTORS

Load factor is the ratio of the average load to the peak load over a designated period. The average load, the maximum average demand for a 15-minute period and the load factors of each farm for July, September, December and March are shown in table 6. Average loads were obtained by dividing the kilowatt-hours used by the number of hours in the metered period. The peak loads are the highest average 15-minute demand periods occurring during the metered period of each month. The average load is in kilowatts and the peak load in kilovolt-amperes; however, the error in load factor resulting from comparing these unlike quantities is not large.

The high average load and load factor of farm 8-1 in March 1951 is of interest. Sixteen 250-watt heat lamps were used on this farm for pig brooding. A 3-kva transformer served this farm.

TABLE 6. LOAD FACTORS OF INDIVIDUAL FARMS, 1950–51.

| Group and farm | July | | | September | | | December | | | March | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Average load kw | Peak demand kva | Load factor | Average load kw | Peak demand kva | Load factor | Average load kw | Peak demand kva | Load factor | Average load kw | Peak demand kva | Load factor |
| **Group I —Range and water heater** | | | | | | | | | | | | |
| 1–1 | 1.070 | 5.6 | .19 | .964 | 4.5 | .21 | 1.200 | 9.9 | .12 | .770 | 5.4 | .14 |
| 7–1 | .751 | 5.8 | .13 | .792 | 4.3 | .18 | 1.500 | 4.6 | .33 | 2.200 | 8.4 | .27 |
| 8–1 | .780 | 4.6 | .17 | .984 | 4.7 | .21 | 1.195 | 5.1 | .23 | 4.440 | 7.8 | .57 |
| 16–1 | .815 | 4.4 | .19 | .864 | 4.2 | .21 | .733 | 4.8 | .15 | .858 | 3.6 | .24 |
| **Group II —Range** | | | | | | | | | | | | |
| 3–2 | .547 | 3.8 | .14 | .660 | 4.1 | .16 | 1.220 | 4.3 | .29 | 1.185 | 4.2 | .28 |
| 9–2 | .321 | 5.0 | .06 | .363 | 4.1 | .09 | .529 | 4.8 | .11 | .970 | 4.1 | .23 |
| 11–2 | .244 | 3.1 | .08 | .107 | 2.9 | .04 | .614 | 3.7 | .17 | .202 | 2.9 | .07 |
| 13–2 | .083 | 3.6 | .02 | — | — | — | .202 | 2.4 | .08 | .131 | 3.1 | .04 |
| **Group III—Water heater** | | | | | | | | | | | | |
| 2–3 | .869 | 3.8 | .23 | .882 | 3.6 | .24 | 1.650 | 4.4 | .38 | — | — | — |
| 4–3 | 1.550 | 5.8 | .27 | 1.390 | 5.1 | .27 | 2.710 | 7.2 | .38 | 2.870 | 5.5 | .52 |
| 12–4 | .534 | 2.6 | .20 | .535 | 1.8 | .30 | 1.625 | 3.4 | .48 | 1.665 | 4.3 | .39 |
| 14–3 | .619 | 3.2 | .19 | .833 | 4.8 | .17 | 1.240 | 4.3 | .29 | 1.190 | 3.3 | .36 |
| 15–3 | .778 | 4.0 | .19 | .607 | 3.9 | .16 | 1.790 | 6.3 | .28 | 1.785 | 5.9 | .30 |
| **Group IV—No range or water heater** | | | | | | | | | | | | |
| 5–4 | .250 | 2.1 | .12 | .256 | 1.6 | .16 | .571 | 2.6 | .22 | — | — | — |
| 6–4 | .196 | 1.7 | .12 | .356 | 1.7 | .21 | .363 | 2.2 | .17 | .547 | 2.3 | .24 |
| 10–4 | .179 | 1.5 | .12 | .250 | 1.5 | .17 | .340 | 1.4 | .24 | .304 | 1.5 | .20 |

## COMPARISON OF THE DEMAND OF THE FARMS IN THIS STUDY WITH THAT OF A RURAL DISTRIBUTION SYSTEM SUBSTATION

A comparison of the demand patterns of the farms studied with that of a large number of farms may increase the value of the data presented. Therefore, the demand curves of a substation serving about 900 farms in Marshall County, Iowa, and the 16 farms are shown in fig. 14. The chart ratio of the demand of the 16 farms to the demand of the substation is 10 to 1. The data for the demand of the 16 farms were compiled from demand records for a week in September for each of the farms. The curve represents a composite day in that the days of the week for each farm were averaged and totaled. The data for the substation were obtained by selecting from the demand meter record at the substation the highest 15-minute demand in each hour for Sept. 24, 1950.

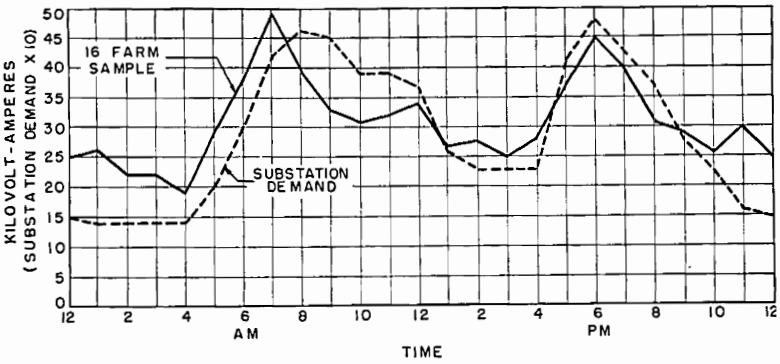



Fig. 14. Comparison of demand of the farms in this study with that of a rural distribution substation, September 1950.

## DEMAND CHARACTERISTICS OF FARM AND HOME APPLIANCES

The operation of many pieces of electrical equipment could be accurately identified on most of the ammeter records. Reciprocating pumps and washers caused the meter to draw a wavy line on the meter records. Many sizes and types of motors with different starting and running currents were used on each farm. The starting and the running current of each motor was the same for every operation provided the load was the same.

Positive identification of the operation of most equipment was impossible in cases involving records obtained from meters with transformer ratios of 100 to 5 and in other instances when many loads were operating in a short period. Non-inductive loads, such as pig and chicken brooders, water heaters, irons, ranges and livestock and poultry waterers, were difficult to identify, particularly if several were in use on one farm. The ranges and the electrical load of the houses of eight cooperators were metered separately to help identify the equipment.

Since many appliances had constant energy demands when in use, the minutes of operation in each half-hour period throughout the week were tabulated for them. The demands of ranges and ironers were variable; for this reason they were tabulated in average amperes per half-hour period. All values of amperes in this study unless otherwise specified are for 115-volt circuits.

### FARM SHOP EQUIPMENT

Many of the farms had a wide variety of electrical shop equipment. Six had power saws, seven had drills, seven had welders and six had tool grinders. Shop equipment was used infrequently, and there was almost complete diversity in its operation among farms and among tools in a given shop. In no case while farms were being metered were two electrical shop tools observed to be operating simultaneously on the same farm. Time of operation and variety of equipment were so great that, except for welders, amount or time of use was not summarized.

Two of the seven welders had 10-kilowatt demands; the others ranged downward in size to 5,280 watts. Welders were infrequently used, and one of the farmers did not use his during any of the 12 weeks when his farm was metered. The seven welders were used on an average of 20.7 minutes for the 12 weeks when they were metered or an average of approximately 85 minutes a year. Figure 15 shows the average number of minutes the welders were used in each month. Most welding was done at times of heavy use of farm machinery. This indicates that these farmers did not usually overhaul and repair their machinery in winter months but used welders to repair equipment after it had broken.

### GRAIN ELEVATORS

Nine of the 16 farms in this study had motor-driven grain elevators; one of the farms had two. Nine of the elevators used 3-hp motors; the other used a 5-hp motor. Although the motors were frequently portable, only the farmer with the 5-hp motor used it for anything except grain elevating. He

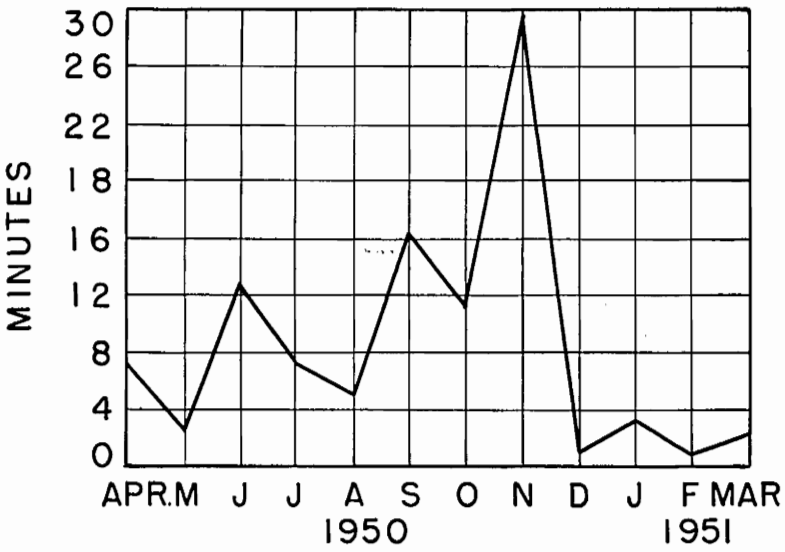



Fig. 15. Welders—average minutes of use per month of seven welders.

occasionally used this motor for driving a wood saw. Several of the elevators were used for oats but practically all elevator use was for corn.

The farmers in this study who had elevators harvested most of their corn between Oct. 30 and Nov. 14, 1950. Several of the farmers did not use their elevators while the farm was metered. Figure 16 is a curve showing the average number of minutes of corn elevator use per half-hour for days in the above period on four farms.

Seven to 15 minutes were usually required to elevate a load of corn. In no instance was an elevator used more than 20 minutes in a half-hour period. The elevators operated an average of 4.9 minutes each half-hour on days they were used. At the time of greatest use the average operating time for elevators was 8.3 minutes.

## MILKING MACHINES

Milking machines were used by 5 of the 16 farmers. Farms using milking machines had 34, 18, 8, 8 and 2 dairy cows. The farmer with two cows used his milking machine even though as few as 6 minutes were required to do the milking.

Sizes of the motors on the milker pumps varied from ¼ hp to 1 hp. The size motor most frequently used was ½ hp.

The average number of minutes the milking machines were used by half-hour periods in the week metered in September

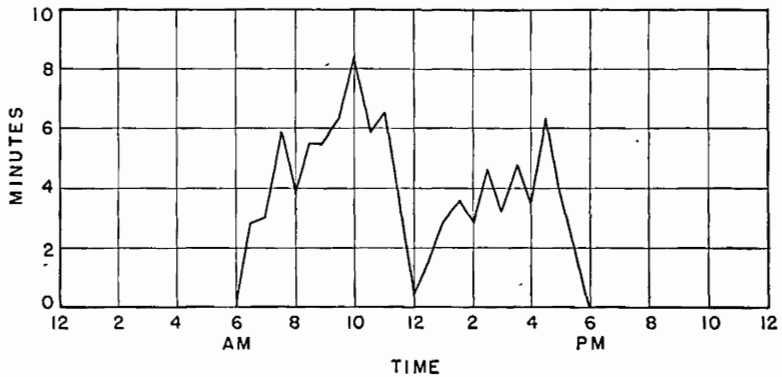



Fig. 16. Grain elevators—average minutes of use per half-hour of four elevators when used in elevating corn, Oct. 30 to Nov. 14, 1950.

1950 is shown in fig. 17. Milking-machine use for the months of July and December 1950, and March 1951, was similar to that of September. The morning peak of average use occurred at the same time for all months and was about the same average minutes operation per half-hour. The evening peak use in July occurred from 6 to 6:30 p. m. and was more diverse than the evening peak of the other months. The greatest average 30-minute use for the evening peaks in July was 7.8 as compared to an average of 13.7 minutes for the other months.

Little difference could be noted in time of use of milking machines by days of the week. The two farmers who milked the most cows were very regular and the other farmers reasonably regular in milking time.

On the basis of average half-hour demand the diversity factor of the five milking machines in this study was 1.7.

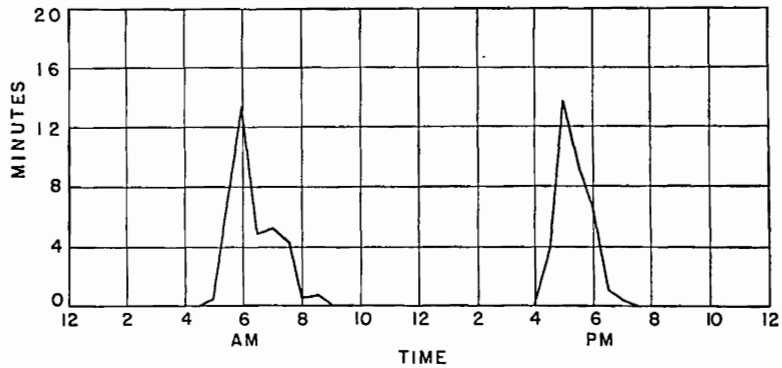



Fig. 17. Milking machines—average minutes of use per half-hour of five milkers, September 1950.

## PIG BROODERS

A total of fifty 250-watt heat lamps were used for pig brooding on seven of the 16 farms. In addition 13 homemade corner pig brooders were used on one of the farms.

Most of the farmers used their pig brooders for only a few days immediately after farrowing. There was almost no use of brooders for pigs farrowed in the fall. One farmer used 14 heat lamps almost continuously for several weeks in the early spring. His electrical energy consumption from Feb. 20 to 27, 1951, was 172 kw-hr and from March 22 to March 30, 1951, 853 kw-hr.

Separate ammeter records of the pig brooder load were obtained for the farm using 14 heat lamps. When the record started on March 20, four lamps were in operation; on March 23, eleven; on March 28, fourteen. The 14 operated continuously until April 4. After this date the brooder lamps were off during the middle of the day and warm nights. The number of lamps was reduced until by April 18 only seven were in use. Metering was discontinued April 20.

## WATER SYSTEMS

All but two of the farms studied had motor-driven pressure water systems which served the home. Ten of the 16 farms used them for both household and farm uses. Water pumps on pressure systems operated frequently and for short intervals; therefore time of operation of these pumps was tabulated in only a few instances.

Nine of the farms owned 11 manually controlled electrically operated pump jacks. Many of the pump jacks were used only as standbys for pressure water systems. The number of minutes of operation per half-hour was tabulated for the five pump jacks which were frequently used. The average of these tabulations for September is shown in fig. 18. Some of these pump jacks operated all night.

Meter records show that peak use of all pumps in this study occurred at times of morning and evening peak energy demands of the entire farm.

## STOCK WATERERS

Seven of the farms in this study had a total of 13 electrically heated stock waterers. Another farm had an electric stock-tank heater. All of the stock waterers were on pressure or gravity water systems, and most of them were rated at either 300 or 787 watts. Twelve of the heaters on the stock waterers were thermostatically controlled; the heater on the other waterer was manually controlled.

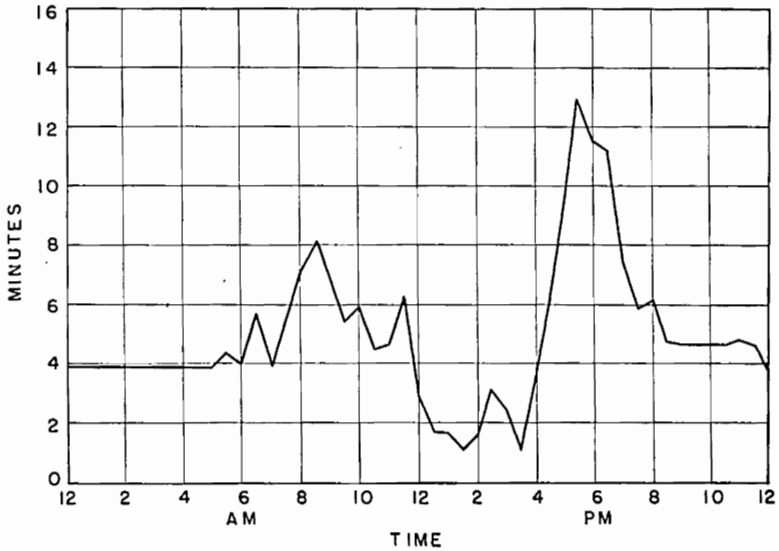



Fig. 18. Pump jacks—average minutes of use per half-hour of five pump jacks, September 1950.

Stock waterers were large users of electricity. Farm 12-4 had three with total connected load of 1,874 watts. This farm used 372 kw-hr of electricity from Feb. 7 to 14, 1951, in contrast to about 90 kw-hr per week in summer and fall months. A watt-hour meter was placed on a 787-watt stock waterer on another farm from Dec. 15, 1950, to Jan. 30, 1951. The stock waterer used 212 kw-hr of electricity for this period.

## RANGES

The eight ranges on the farms in this study were metered from July 1950 through February 1951. Their demand was tabulated in average amperes per 30 minutes. The greatest instantaneous demand of each week, the time of its occurrence and its duration were also noted in the tabulation. It was necessary to include a stoker in the meter circuit of one range and a water heater, a dishwasher, a blower and an igniter for an oil furnace in the circuit of another. The loads of these and any equipment which was connected to the range convenience outlet were omitted from the tabulation when it was possible to distinguish them.

Table 7 shows the average demand in amperes of the eight ranges in this study by half-hour periods for weeks in July, September and November 1950, and January 1951. The values of amperes in this table are for 115-volt circuits. Figure 19

TABLE 7. AVERAGE DEMAND IN AMPERES OF EIGHT RANGES BY HALF-HOUR PERIODS FOR WEEKS IN JULY, SEPTEMBER AND NOVEMBER 1950, AND JANUARY 1951.

| Month and Day | HRS. A.M. 12:00 | 12:30 | 1:00 | 1:30 | 2:00 | 2:30 | 3:00 | 3:30 | 4:00 | 4:30 | 5:00 | 5:30 | 6:00 | 6:30 | 7:00 | 7:30 | 8:00 | 8:30 | 9:00 | 9:30 | 10:00 | 10:30 | 11:00 | HRS. A.M. 11:30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July | | | | | | | | | | | | | | | | | | | | | | | | |
| Sunday | — | — | — | — | — | — | — | — | — | — | — | 2.5 | 4.0 | 1.9 | 4.7 | 4.8 | 3.4 | 0.3 | 3.7 | 4.9 | 2.4 | 1.0 | 1.4 | 2.1 |
| Monday | — | 0.3 | — | — | — | — | — | — | — | — | — | 1.0 | 0.8 | 2.4 | 3.5 | 1.7 | 2.3 | 0.8 | 2.1 | 2.8 | 1.5 | 2.9 | 13.3 | 9.6 |
| Tuesday | — | — | — | — | — | — | — | — | — | — | 0.1 | 0.5 | 2.2 | 3.0 | 6.0 | 0.5 | 2.4 | 3.2 | 2.7 | 1.6 | 1.3 | 2.4 | 7.9 | 8.6 |
| Wednesday | — | — | — | — | — | — | 0.5 | 0.4 | — | — | — | 1.3 | 0.3 | 4.0 | 4.3 | 2.3 | 2.9 | 1.1 | 1.0 | — | 2.2 | 9.5 | 2.7 | 2.4 |
| Thursday | — | — | — | — | — | — | — | — | — | — | 2.0 | 0.1 | 1.4 | 5.3 | 5.8 | 2.2 | 1.9 | 4.4 | 1.6 | 1.7 | 7.2 | 9.2 | 9.0 | 9.0 |
| Friday | — | — | — | — | — | — | — | — | — | — | 3.3 | 4.7 | 3.4 | 2.7 | 2.4 | 3.7 | 1.3 | 2.0 | 2.0 | 2.3 | 2.3 | 5.1 | 13.5 | 6.4 |
| Saturday | — | — | — | — | — | — | — | — | — | — | — | — | 4.7 | 4.4 | 0.7 | 4.5 | 2.4 | 4.8 | 5.9 | 5.1 | 5.4 | 3.7 | 4.9 | 11.2 |
| September | | | | | | | | | | | | | | | | | | | | | | | | |
| Sunday | — | — | — | — | — | — | — | — | — | — | 1.1 | 2.3 | 0.7 | 2.9 | 5.2 | 4.7 | 4.1 | 1.7 | 2.4 | 1.7 | 1.5 | 0.8 | 2.9 | 3.1 |
| Monday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 2.4 | 2.9 | 1.5 | 1.5 | 0.2 | 0.8 | — | 1.4 | 2.5 | 4.0 |
| Tuesday | — | — | — | — | — | — | — | — | — | — | 2.3 | 3.8 | 0.9 | 2.0 | 5.3 | 4.3 | 1.4 | 0.4 | — | 3.1 | 1.3 | 0.6 | 4.3 | 7.8 |
| Wednesday | — | — | — | — | — | 0.4 | — | — | — | — | — | — | — | 0.9 | 4.5 | 3.4 | 0.9 | 1.4 | 3.8 | 2.4 | 3.6 | 5.8 | 3.1 | 2.9 |
| Thursday | — | — | — | — | 0.4 | — | — | — | — | — | — | — | 1.1 | 2.1 | 3.6 | 4.4 | 4.2 | 2.6 | 2.1 | 2.3 | 1.8 | 2.5 | 2.4 | 2.3 |
| Friday | — | — | — | — | — | — | — | — | — | — | 0.6 | 0.6 | 3.4 | 1.6 | 7.4 | 6.7 | 3.9 | 2.1 | — | 1.1 | 1.5 | 1.9 | 2.9 | 4.7 |
| Saturday | — | — | — | — | — | — | — | — | — | — | 0.3 | 1.3 | 5.0 | 4.7 | 2.9 | 4.9 | 7.2 | 4.8 | 3.4 | 2.6 | 2.6 | 4.9 | 4.7 | 5.9 |
| November | | | | | | | | | | | | | | | | | | | | | | | | |
| Sunday | — | — | — | — | — | — | — | — | — | — | — | 0.3 | — | 4.0 | 0.7 | 9.4 | 5.3 | 6.4 | 2.4 | 2.5 | 2.4 | 1.5 | 1.2 | 1.1 |
| Monday | — | — | — | — | — | — | — | — | — | — | — | — | 0.5 | 4.1 | 6.5 | 3.9 | 2.7 | 0.4 | — | 0.4 | 1.4 | 2.2 | 4.9 | 4.2 |
| Tuesday | — | — | — | — | — | — | — | — | — | 0.3 | 3.5 | 2.4 | — | 1.7 | 5.0 | 0.9 | 1.9 | 7.5 | 4.3 | 2.6 | 1.6 | 4.3 | 4.2 | 7.0 |
| Wednesday | — | — | — | — | — | — | — | — | — | — | — | 0.4 | 3.1 | 2.2 | 3.5 | 2.5 | 2.9 | 5.9 | 3.6 | 3.3 | 2.6 | 2.6 | 2.4 | 2.8 |
| Thursday | — | — | — | — | — | — | — | — | — | — | 0.6 | 2.6 | 2.2 | 0.7 | 0.7 | 2.8 | 0.5 | 1.6 | 3.0 | 2.6 | 2.0 | 0.9 | 1.9 | 5.7 |
| Friday | — | 0.2 | — | — | — | — | — | — | — | 0.6 | 1.4 | — | 0.8 | 0.0 | 3.7 | 1.5 | 1.9 | 2.6 | 6.4 | 4.4 | 3.1 | 3.2 | 6.2 | 6.8 |
| Saturday | — | — | — | — | — | — | — | — | — | — | — | 3.5 | 4.4 | 1.7 | 5.5 | 3.2 | 2.6 | 3.0 | 3.2 | 2.2 | 4.8 | 3.4 | 8.1 | 9.0 |
| January | | | | | | | | | | | | | | | | | | | | | | | | |
| Sunday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 0.9 | 0.6 | 1.8 | 8.5 | 4.7 | 0.1 | 0.7 | 0.5 | 0.6 | 0.5 |
| Monday | — | — | — | — | — | — | — | — | — | — | — | — | 2.0 | 2.5 | 2.1 | 2.8 | 2.4 | 0.4 | 0.9 | 9.3 | 0.4 | 0.1 | 3.5 | 3.2 |
| Tuesday | — | — | — | — | — | — | — | — | — | — | 2.1 | 2.3 | 0.9 | 0.1 | 0.8 | 2.9 | 2.6 | — | 1.4 | 0.4 | — | — | 1.1 | — |
| Wednesday | — | — | — | — | — | — | — | — | — | — | 0.9 | — | — | — | 3.2 | 5.5 | 1.6 | 0.7 | 0.9 | 1.8 | 0.9 | 1.4 | 0.2 | 1.7 |
| Thursday | — | — | — | — | — | — | — | — | — | — | 1.6 | — | — | 2.9 | 2.3 | 3.7 | 1.2 | 0.2 | 0.9 | 0.1 | — | 1.3 | 2.9 | 2.7 |
| Friday | — | — | — | — | — | — | — | — | — | — | — | — | 2.3 | 1.5 | 1.3 | 3.3 | 5.0 | 2.3 | 2.8 | 1.7 | 1.8 | 1.5 | 2.0 | 3.9 |
| Saturday | 0.2 | 0.2 | 0.2 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 | 0.1 | 0.2 | 0.5 | 4.5 | 0.7 | 0.9 | 0.2 | 0.8 | 0.5 | 2.0 | 3.5 | 1.0 | 0.2 | — | — | — |

TABLE 7.—CONTINUED.

| MONTH AND DAY | HRS. P.M. 12:00 | 12:30 | 1:00 | 1:30 | 2:00 | 2:30 | 3:00 | 3:30 | 4:00 | 4:30 | 5:00 | 5:30 | 6:00 | 6:30 | 7:00 | 7:30 | 8:00 | 8:30 | 9:00 | 9:30 | 10:00 | 10:30 | 11:00 | HRS. P.M. 11:30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July | | | | | | | | | | | | | | | | | | | | | | | | |
| Sunday | 5.2 | 0.3 | — | — | — | — | — | 1.6 | 1.4 | 3.6 | 3.6 | 2.8 | 2.8 | 0.4 | 1.6 | 0.3 | — | — | — | — | — | 0.6 | — | — |
| Monday | 4.4 | 1.4 | 0.6 | 1.5 | 2.8 | 1.1 | 0.2 | 0.7 | 2.3 | — | — | 1.8 | 2.3 | 2.0 | 3.2 | 2.0 | 0.3 | — | — | — | — | — | — | — |
| Tuesday | 3.3 | 4.7 | 1.0 | — | — | — | 0.6 | 0.5 | — | 1.2 | 1.8 | 3.2 | 6.1 | 3.2 | 3.1 | 1.0 | 1.2 | 1.9 | 1.6 | 0.7 | — | — | — | — |
| Wednesday | 2.5 | 3.2 | 1.1 | 1.2 | 3.6 | 0.2 | — | 0.4 | 2.9 | 4.8 | 6.6 | 3.6 | 6.8 | 1.3 | 1.7 | 4.3 | 0.8 | 0.5 | — | 1.0 | 0.2 | — | — | — |
| Thursday | 4.0 | 3.3 | — | 3.6 | 2.5 | 3.0 | 2.7 | 3.0 | 6.3 | 2.5 | 1.8 | 2.4 | 6.8 | 1.9 | 0.6 | 0.1 | 0.3 | 0.5 | — | 0.5 | — | — | — | — |
| Friday | 2.2 | — | 1.2 | — | 0.4 | 0.9 | 2.3 | 0.4 | 1.1 | 0.3 | 0.1 | 0.7 | 2.2 | 2.6 | 3.0 | 0.7 | 0.4 | — | 0.3 | 0.3 | — | — | — | — |
| Saturday | 5.0 | 1.2 | 2.2 | 2.6 | 1.7 | 2.2 | 4.5 | 3.7 | 5.5 | 3.0 | 1.7 | 2.6 | 0.7 | 3.7 | 1.5 | 1.2 | 0.3 | 0.3 | — | — | — | — | — | — |
| September | | | | | | | | | | | | | | | | | | | | | | | | |
| Sunday | 5.5 | 4.2 | 1.5 | — | — | — | — | — | — | — | — | 0.1 | — | — | 0.4 | 0.6 | 0.8 | — | — | — | — | — | — | — |
| Monday | 6.0 | 1.4 | 5.8 | 5.6 | 2.1 | 0.3 | 2.0 | 0.7 | 0.2 | 1.9 | 1.5 | 2.5 | 3.6 | 1.0 | 3.1 | 1.4 | 2.0 | 1.0 | 0.6 | 0.4 | 0.5 | — | — | — |
| Tuesday | 4.3 | 1.9 | 0.5 | — | — | — | — | — | — | 0.6 | — | 1.3 | 1.4 | 1.9 | 2.4 | — | — | — | — | — | — | — | — | 0.2 |
| Wednesday | 2.3 | 2.7 | 0.8 | 1.6 | 1.0 | — | 4.0 | 2.8 | 6.0 | 1.4 | 0.9 | 3.7 | 7.4 | 5.7 | 3.1 | 1.2 | 0.2 | 1.0 | 0.2 | 1.5 | 0.1 | — | — | — |
| Thursday | 2.1 | — | — | — | 1.5 | 1.2 | 1.3 | — | 0.1 | 0.7 | 0.4 | — | 2.1 | 3.0 | 3.9 | 0.2 | 0.1 | 0.4 | — | 2.1 | 2.5 | 0.6 | — | — |
| Friday | 3.8 | 0.3 | 0.5 | 1.7 | 0.8 | 0.8 | 2.7 | 3.1 | 0.7 | — | 1.8 | 1.5 | 4.5 | 4.8 | 1.4 | 1.9 | — | — | — | — | — | — | — | — |
| Saturday | 8.3 | 2.7 | 2.5 | 0.6 | 1.0 | 2.5 | 6.1 | 3.9 | 4.1 | 5.6 | 4.9 | 3.7 | 1.2 | 2.5 | 7.2 | 0.9 | — | — | — | — | — | — | — | — |
| November | | | | | | | | | | | | | | | | | | | | | | | | |
| Sunday | 4.1 | 5.8 | 1.5 | 1.8 | 2.6 | 2.3 | 0.4 | — | — | — | 0.8 | 0.4 | 0.5 | 0.2 | — | 0.5 | 0.5 | — | — | — | — | — | — | — |
| Monday | 3.6 | 1.2 | 1.6 | 1.3 | 2.1 | 1.7 | 1.4 | 0.9 | — | 2.1 | 2.0 | 6.4 | 3.6 | 0.6 | 0.4 | — | — | — | — | — | 0.1 | 0.7 | — | — |
| Tuesday | 4.9 | 3.8 | 2.5 | 3.8 | 3.8 | 3.4 | 2.5 | 2.2 | 0.4 | 1.0 | 1.7 | 5.2 | 3.0 | 1.1 | — | — | 0.3 | — | — | — | 0.2 | — | — | — |
| Wednesday | 1.6 | 1.3 | 1.4 | 1.6 | — | — | — | 1.9 | 1.5 | 2.3 | 5.1 | 5.4 | 8.7 | 5.7 | 3.0 | 2.0 | — | — | 0.4 | — | — | — | — | — |
| Thursday | 1.0 | — | — | — | — | 0.4 | — | 0.5 | 0.3 | 0.6 | 0.5 | 1.5 | 2.4 | 4.8 | 0.6 | 0.1 | — | 0.6 | 0.2 | — | 0.6 | 0.1 | — | — |
| Friday | 1.8 | 0.5 | 0.7 | 0.3 | — | 0.8 | — | — | — | — | 0.1 | 5.7 | 9.2 | 1.8 | 1.5 | 0.2 | — | — | — | — | — | — | 0.3 | — |
| Saturday | 3.4 | 1.0 | — | 1.1 | 0.6 | 0.7 | 0.5 | 1.3 | 0.4 | 1.4 | 1.3 | 8.0 | 2.1 | 2.1 | 0.2 | 0.2 | 0.2 | 0.5 | 0.5 | 0.2 | — | — | — | — |
| January | | | | | | | | | | | | | | | | | | | | | | | | |
| Sunday | 2.9 | 9.3 | 2.5 | 1.7 | 1.6 | 2.9 | 1.5 | 0.2 | — | — | 2.0 | 0.9 | 2.8 | 0.3 | 0.7 | 0.2 | 0.4 | 0.3 | — | — | 0.8 | 2.0 | — | — |
| Monday | 2.1 | 5.1 | 2.2 | 1.2 | 1.5 | 1.3 | 2.9 | 3.3 | 0.9 | 1.6 | 0.8 | 2.8 | 1.7 | 0.6 | — | 0.2 | 0.4 | — | — | 0.3 | — | — | — | — |
| Tuesday | 2.9 | 1.7 | 0.7 | 0.5 | — | — | 0.2 | 2.3 | 2.6 | 4.1 | 4.0 | 3.7 | 1.8 | 3.9 | 1.3 | — | 0.4 | — | — | — | — | — | — | — |
| Wednesday | 3.2 | 0.7 | 0.8 | 1.5 | 1.7 | 0.4 | 0.9 | 1.1 | 1.8 | 0.4 | 2.9 | 5.0 | 5.0 | 0.8 | 0.7 | — | — | — | — | — | — | — | — | — |
| Thursday | 2.9 | 3.0 | 3.2 | 2.3 | 1.7 | 1.3 | 1.1 | 0.6 | 0.7 | 0.4 | 1.0 | 7.4 | 6.6 | 0.7 | — | — | — | — | — | — | — | — | — | — |
| Friday | 4.9 | 1.8 | 1.2 | 4.1 | 2.8 | 1.7 | 1.2 | 1.9 | 1.9 | 2.5 | 2.6 | 6.1 | 2.2 | 1.4 | 0.7 | 0.1 | 0.5 | 0.3 | 0.2 | 0.2 | 0.1 | 0.2 | 0.2 | 0.1 |
| Saturday | 4.0 | 1.3 | 1.2 | 0.7 | 0.2 | 1.2 | — | — | 0.4 | 0.6 | 1.1 | 3.0 | 4.1 | 3.6 | 1.2 | 0.6 | 0.3 | — | — | — | — | — | — | — |

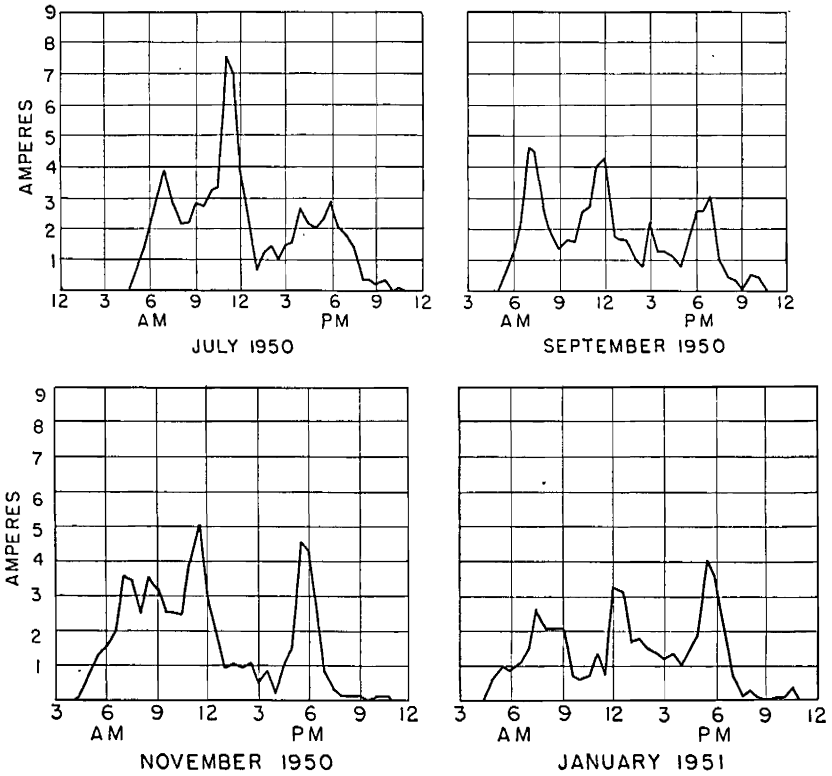



Fig. 19. Ranges—average demand in amperes per half-hour for eight ranges, average day for each month.

shows the average daily demand for the metered week for each of the months mentioned. In computing averages for a month it was necessary to add data from records which were not recorded simultaneously. For example, demands for the 7th, 14th, 21st and 28th days of a month might have entered into averages for a single day.

Peak demands occurred most often from 7 to 8:30 a. m., from 11 a. m. to noon and from 5:30 to 6:30 p. m. Of these the highest usually occurred at midday in July and September, in the morning in November, and in the evening in January. When these 4 months are considered together, midday peaks accounted for half of the daily maximums, and morning and evening peaks for an equal number of the remainder.

Peaks were highest in July. They tended to decrease in height from July to January. For the 4 months represented there was a tendency for peaks to be higher on Friday, Satur-

day and Sunday in descending order. They tended to be lowest on Thursday.

Greatest use occurred before noon in July, September and November. It occurred after noon in January. Average daily use was greatest in July and decreased from July to January. Part of the decrease in use may be attributed to fall and winter use of coal ranges for cooking. There was also a decrease in use of electric ranges by cooperators who did not use coal for cooking during winter months.

Compilations of the data from which table 7 was derived show that average daily use was greatest on Saturday, Friday and Wednesday, in descending order, and lowest on Sunday.

Table 8 shows demand characteristics of the ranges in this study. The data presented are based on demands of 1 minute or more and on average 30-minute demands. Demand factors are commonly based on 15-minute demand intervals. The time intervals used give an approximation of the usual demand factor, the one based on 1-minute periods being higher and the one based on 30-minute periods lower.

Table 8 shows that individual peak demands and highest average 30-minute demands are distributed among the early morning, midday and evening peak periods as well as among the days of the week.

Load factors of ranges are shown in table 9. The maximum 30-minute loads in the column headed "All Farms" are the highest simultaneous demands in amperes of all the ranges on which data are available. Load factors of individual ranges by months varied from 0.094 to 0.009. The load factor of all the ranges in this study for the 8-month period was 0.083.

The diversity factor for the ranges considered was 2.55 for the periods metered from July to February inclusive. In computing this factor the maximum demand of the ranges as a group was found by assuming demands to be simultaneous if they occurred in the same half-hour of the same day of different weeks in the month as explained previously. The average demand was the composite average of the eight periods metered.

## WATER HEATERS

Of the nine water heaters in this study two were controlled so that they should be off from 7 a. m. to 11 p. m., and another was controlled so that it should be off from 5:30 to 8 a. m., from 11 a. m. to 1 p. m. and from 4:30 to 7 p. m. Since time-control influences use patterns, water heaters with each type of control and those not controlled were considered separately in computing average demands.

Minutes of operation in each half-hour were tabulated from

TABLE 8. DEMAND CHARACTERISTICS OF RANGES, JUNE 1950 TO FEBRUARY 1951.

| Cooperator | 1–1 | 3–2 | 7–1 | 8–1 | 9–2 | 11–2 | 13–2 | 16–1 |
|---|---|---|---|---|---|---|---|---|
| Connected load–watts | 16,300 | 9,500 | 10,010 | 11,950 | 10,800 | 9,900 | 9,500 | 10,010 |
| Peak demand of 1–minute or more | | | | | | | | |
| Date | Dec. 31 | Jan. 28 | June 30 | July 9 | Oct. 21 | Aug. 3 | Aug. 25 | Oct. 11 |
| Day | Sunday | Sunday | Friday | Sunday | Saturday | Thursday | Friday | Wednesday |
| Time | 11:43 p.m. | 12:36 p.m. | 10:48 a.m. | 6:02 p.m. | 8:30 p.m. | 6:29 a.m. | 5:49 a.m. | 11:29 a.m. |
| Duration | 1 min. | 1 min. | 4 min. | 3 min. | 5 min. | 1 min. | 8 min. | 1 min. |
| Amperes | 99 | 58 | 52 | 45 | 66 | 40 | 47 | 54 |
| Volts | 96 | 114 | 108 | 113 | 104 | 110 | 113 | 113 |
| Volt–amperes | 9,504 | 6,612 | 5,616 | 5,085 | 6,864 | 4,400 | 5,311 | 6,112 |
| Demand factor | .583 | .696 | .562 | .426 | .636 | .444 | .559 | .611 |
| Highest 30–minute average demand | | | | | | | | |
| Date | Dec. 31 | Nov. 22 | June 30 | Jan. 23 | Oct. 21 | Feb. 18 | Aug. 24 | Sept. 18 |
| Day | Sunday | Wednesday | Friday | Tuesday | Saturday | Sunday | Thursday | Monday |
| Time | 11:30 p.m. | 5:00 p.m. | 11:00 a.m. | 6:30 p.m. | 8:30 p.m. | 6:00 p.m. | 9:30 a.m. | 1:30 p.m. |
| Amperes | 81.8 | 27.68 | 27.90 | 24.96 | 45.60 | 29.92 | 35.20 | 31.20 |
| Volts | 99 | 113 | 113 | 118 | 110 | 105 | 104 | 110 |
| Volt–amperes | 8,098 | 3,128 | 3,153 | 2,945 | 5,016 | 3,142 | 3,661 | 3,432 |
| Demand factor | .497 | .329 | .315 | .246 | .464 | .317 | .385 | .343 |

TABLE 9. LOAD FACTORS OF RANGES, JULY 1950 TO FEBRUARY 1951.

| Cooperator | 1–1 | 3–2 | 7–1 | 8–1 | 9–2 | 11–2 | 13–2 | 16–1 | All Farms |
|---|---|---|---|---|---|---|---|---|---|
| July | | | | | | | | | |
| Average load amps. | 3.33 | 1.14 | 1.11 | .91 | 2.16 | 1.60 | 1.22 | 1.87 | 1.67 |
| Max. 30–min. load amps. | 36.40 | 19.2 | 19.7 | 23.5 | 39.0 | 22.6 | 28.8 | 24.5 | 13.3 |
| Load factor | .092 | .059 | .056 | .039 | .055 | .071 | .042 | .076 | .126 |
| August | | | | | | | | | |
| Average load amps. | | 1.67 | .91 | | 2.60 | .65 | 1.70 | | 1.51 |
| Max. 30–min. load amps. | | 21.1 | 14.7 | | 34.3 | 14.0 | 35.2 | | 16.9 |
| Load factor | | .079 | .062 | | .076 | .046 | .048 | | .089 |
| September | | | | | | | | | |
| Average load amps. | 2.86 | 1.52 | 1.17 | 1.18 | 1.62 | .88 | 1.11 | 1.37 | 1.46 |
| Max. 30–min. load amps. | 30.40 | 23.6 | 17.2 | 20.3 | 18.3 | 18.4 | 28.0 | 31.2 | 8.3 |
| Load factor | .094 | .064 | .068 | .058 | .088 | .048 | .040 | .044 | .176 |
| October | | | | | | | | | |
| Average load amps. | 4.28 | .92 | .88 | | 2.94 | 1.05 | .67 | 1.01 | 1.68 |
| Max. 30–min. load amps. | 53.0 | 13.4 | 21.0 | | 45.6 | 15.04 | 19.9 | 19.1 | 12.6 |
| Load factor | .081 | .069 | .042 | | .065 | .070 | .034 | .053 | .133 |
| November | | | | | | | | | |
| Average load amps. | 4.06 | .72 | 1.16 | .60 | 1.68 | 1.05 | .39 | 1.31 | 1.49 |
| Max. 30–min. load amps. | 43.40 | 27.68 | 14.48 | 18.8 | 27.8 | 21.62 | 13.04 | 25.60 | 9.4 |
| Load factor | .094 | .026 | .080 | .032 | .060 | .049 | .030 | .051 | .159 |
| December | | | | | | | | | |
| Average load amps. | 4.00 | 1.29 | .82 | 1.16 | .79 | .77 | .23 | | 1.29 |
| Max. 30–min. load amps. | 81.8 | 17.1 | 17.6 | 18.8 | 27.12 | 17.52 | 10.80 | | 11.7 |
| Load factor | .049 | .075 | .047 | .062 | .029 | .044 | .021 | | .110 |
| January | | | | | | | | | |
| Average load amps. | 3.26 | .97 | .73 | .83 | .86 | .67 | .06 | 1.02 | 1.05 |
| Max. 30–min. load amps. | 45.8 | 16.16 | 19.0 | 24.96 | 22.5 | 16.16 | 6.72 | 18.9 | 8.5 |
| Load factor | .071 | .060 | .038 | .033 | .038 | .041 | .009 | .054 | .124 |
| February | | | | | | | | | |
| Average load amps. | 2.09 | .72 | 1.25 | .91 | 1.93 | 1.44 | .05 | .42 | 1.10 |
| Max. 30–min. load amps. | 34.0 | 15.68 | 24.0 | 16.64 | 22.24 | 29.92 | 4.24 | 11.12 | 7.0 |
| Load factor | .062 | .046 | .052 | .055 | .087 | .048 | .012 | .038 | .157 |
| Eight-month period | | | | | | | | | |
| Average load amps. | 3.41 | 1.12 | 1.00 | .93 | 1.82 | 1.01 | .68 | 1.17 | 1.41 |
| Max. 30–min. load amps. | 81.8 | 27.68 | 24.0 | 24.96 | 45.6 | 29.92 | 35.2 | 31.2 | 16.9 |
| Load factor | .042 | .041 | .042 | .037 | .040 | .034 | .019 | .038 | .083 |

meter records. If a water heater had two heating units, the time of operation of each unit was tabulated whenever such operation could be detected by inspection of meter charts. The time was weighted to account for the use of the larger unit or of both units. Therefore, in the cases of two water heaters, there were some instances of more than 30-minutes use per half-hour.

Six water heaters had no time control. The average number of minutes of use per half-hour of the heaters in September 1950, is shown in table 10. The operation of these heaters in July, September and November 1950, and January 1951, is summarized in fig. 20.

The table for September shows that use and peaks of the water heaters in this study are fairly evenly distributed among the days. Peak demands usually occurred from 7 to 8 p. m. and from 7 to 8:30 a. m. Use tended to be low during the night.

The monthly summary curves show that morning demand tends to form a peak between 8 and 8:30 a. m. and evening demand from 6:30 to 7:30 p. m. Evening peaks tended to be

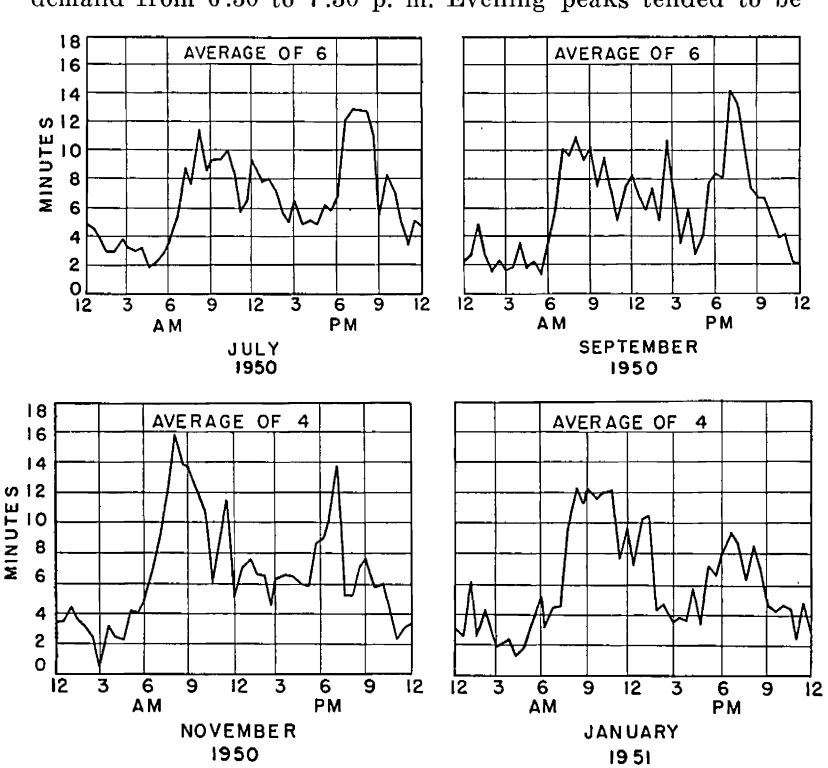



Fig. 20. Water heaters not on off-peak control—minutes of use per half-hour, average day for each month.

TABLE 10. AVERAGE MINUTES OF USE PER HALF-HOUR OF SIX WATER HEATERS NOT ON OFF-PEAK CONTROL FOR A WEEK IN SEPTEMBER 1950.

| Day of Week | HRS. A.M. 12:00 | 12:30 | 1:00 | 1:30 | 2:00 | 2:30 | 3:00 | 3:30 | 4:00 | 4:30 | 5:00 | 5:30 | 6:00 | 6:30 | 7:00 | 7:30 | 8:00 | 8:30 | 9:00 | 9:30 | 10:00 | 10:30 | 11:00 | HRS. A.M. 11:30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sunday | 1.2 | 1.5 | 6.7 | 1.2 | 1.2 | — | 3.3 | 5.0 | 7.3 | 2.3 | 4.7 | 2.3 | 2.5 | 1.5 | 0.8 | 12.0 | 5.5 | 11.5 | 11.8 | 9.3 | 15.7 | 7.0 | 3.3 | 5.8 |
| Monday | — | 1.2 | 3.8 | 5.0 | 3.3 | 7.7 | 2.0 | 0.8 | 0.5 | 2.2 | 1.2 | 1.5 | 3.0 | 8.0 | 10.1 | 15.8 | 8.3 | 11.8 | 6.5 | 8.8 | 14.7 | 11.5 | 5.2 | 4.5 |
| Tuesday | 1.2 | 1.2 | 1.2 | 4.5 | 1.8 | 1.2 | 1.8 | 7.3 | 4.5 | 1.8 | 1.2 | — | 1.3 | 6.3 | 12.3 | 12.3 | 14.3 | 7.0 | 7.8 | 2.5 | 4.3 | 1.6 | 7.0 | 10.5 |
| Wednesday | 3.8 | 4.0 | 10.7 | 2.3 | 1.3 | 2.3 | 1.3 | — | 3.7 | — | 2.5 | 2.7 | 5.8 | 4.8 | 7.3 | 16.0 | 17.2 | 6.3 | 9.2 | 11.2 | 7.0 | 6.8 | 5.3 | 8.8 |
| Thursday | 3.8 | 2.5 | 7.2 | 5.8 | 2.5 | 1.2 | 2.0 | 0.3 | 2.8 | 3.5 | 1.2 | 8.4 | 10.0 | 11.2 | 18.8 | 12.3 | 12.0 | 6.7 | 13.2 | 7.5 | 3.8 | — | 2.5 | 12.2 |
| Friday | 2.2 | 3.2 | 6.0 | 2.0 | — | 1.2 | — | 0.7 | 4.5 | 0.3 | 2.0 | 2.7 | 2.7 | 8.2 | 14.0 | 8.0 | 10.3 | 11.3 | 18.7 | 9.2 | 11.7 | 12.2 | 7.7 | 5.2 |
| Saturday | 3.5 | 6.2 | 2.0 | — | 1.2 | 4.0 | 3.0 | — | 3.5 | 4.7 | 3.7 | — | 2.7 | 2.7 | 10.0 | 13.8 | 12.2 | 11.3 | 7.0 | 4.0 | 12.3 | 6.3 | 5.0 | 8.7 |

TABLE 10.—Continued.

| Day of Week | HRS. P.M. 12:00 | 12:30 | 1:00 | 1:30 | 2:00 | 2:30 | 3:00 | 3:30 | 4:00 | 4:30 | 5:00 | 5:30 | 6:00 | 6:30 | 7:00 | 7:30 | 8:00 | 8:30 | 9:00 | 9:30 | 10:00 | 10:30 | 11:00 | HRS. P.M. 11:30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sunday | 11.8 | 3.8 | 5.7 | 10.8 | 2.0 | 7.8 | 7.0 | 2.5 | 5.7 | 3.8 | — | 5.8 | 10.8 | 7.5 | 6.0 | 12.5 | 6.5 | 2.8 | 3.7 | 6.8 | 2.8 | 4.8 | — | 3.7 |
| Monday | 8.0 | 4.7 | 4.2 | 6.2 | 8.5 | 20.0 | 8.7 | 5.2 | 5.2 | 1.5 | 5.0 | 8.3 | 8.2 | 5.3 | 13.3 | 16.8 | 12.5 | 8.7 | 12.2 | 2.7 | 3.5 | 3.2 | 4.3 | 5.7 |
| Tuesday | 13.0 | 8.3 | 10.3 | 13.3 | 7.7 | 8.7 | 3.2 | 0.7 | 9.3 | 1.7 | 1.3 | 7.5 | 1.3 | 6.5 | 16.8 | 12.0 | 9.0 | 6.3 | 5.3 | 6.2 | 9.0 | 5.3 | 3.8 | 1.8 |
| Wednesday | 6.0 | 8.7 | 7.8 | 8.7 | — | 9.0 | 13.4 | 6.8 | 6.3 | 5.0 | 7.0 | 12.2 | 5.7 | 6.2 | 21.8 | 10.7 | 6.3 | 6.3 | 5.8 | 13.2 | 8.8 | 2.8 | 3.0 | 2.3 |
| Thursday | 2.3 | 10.0 | 0.8 | 6.0 | 1.7 | 10.2 | 9.0 | 6.0 | 6.5 | 2.5 | 2.0 | 4.5 | 14.8 | 11.8 | 14.2 | 20.8 | 12.7 | 8.0 | 1.5 | 9.5 | 4.7 | 5.0 | 6.0 | — |
| Friday | 7.5 | 7.3 | 2.7 | 8.2 | 8.3 | 5.5 | 5.0 | 0.7 | 1.2 | 1.8 | 7.5 | 11.0 | 8.0 | 10.5 | 20.5 | 10.5 | 3.7 | 5.2 | 9.0 | 4.3 | 1.3 | 2.5 | 1.2 | 1.2 |
| Saturday | 13.0 | 6.7 | 11.0 | 3.0 | 5.5 | 14.5 | 7.5 | 4.2 | 8.8 | 3.7 | 6.0 | 8.7 | 12.8 | 12.8 | 9.5 | 11.3 | 16.0 | 16.3 | 11.3 | 6.3 | 8.7 | 4.3 | 11.2 | 2.7 |

highest in July and September and morning peaks in November and January. While there was not much variation in use from month to month, it was greatest in November and lowest in September.

Although peak demands of water heaters without time control tended to come later than the peaks for the whole farms, their times of high use came when other use was high and their periods of low use came when other use was low.

Curves showing the time of operation of the two water heaters which should be off from 7 a. m. to 11 p. m. are shown in figs. 21 and 22. The controls for these are timed electrically so that whenever a power outage occurs the timing is made slow by a period equal to the length of the outage. These controls are reset manually by the power company.

Curves A and B in fig. 21 show examples of a single day of operation for each of 2 months. On Sunday, July 23, one was timed improperly and operated from 4:42 a. m. to 12:42 p. m. On Friday, Sept. 15, both were timed very nearly correctly. Peak usage was from 11 p. m. to 2:30 a. m. No use occurred after 5:30 a. m. These two examples show that when such controls are not properly set they may defeat their purpose entirely.

Curves in fig. 22 show average daily use for a week in July, September, November and January. In July neither heater was in use from 1 to 11 p. m. In September this was true from 6:30 a. m. to 10:30 p. m.; in November, from 8 a. m. to 10:30 p. m.; and in January, from 8:30 a. m. to 11:30 p. m. Thus, morning peaks for farms were not entirely avoided by the use of time controls except in September, the only one of these months when both controls were timed correctly.

Average peak periods occurred at the following times: July, 5:30 to 6:30 a. m.; September, 11 p. m. to 1 a. m.; November, midnight to 1:30 a. m.; and January, 12:30 to 2 a. m. If the controls had been timed properly, all peaks should have begun at 11 p. m.

The water heater on farm 1-1 operated in much the same manner as those which were not controlled except that it was always off from 5:30 to 8 a. m., 11 a. m. to 1 p. m. and from 4:30 to 7 p. m. The control of this heater was operated from a control clock in the kitchen which was also used to indicate the time and which could be set by the farmer. This water heater was on less from midnight to 7 a. m. than from 7 to 10 a. m.; the latter period was a time of high demand. This water heater showed similar operation on other days.

### LAUNDRY EQUIPMENT

Laundry equipment included 12 nonautomatic washers, 5 automatic washers, 16 irons and 8 ironers. One cooperator had

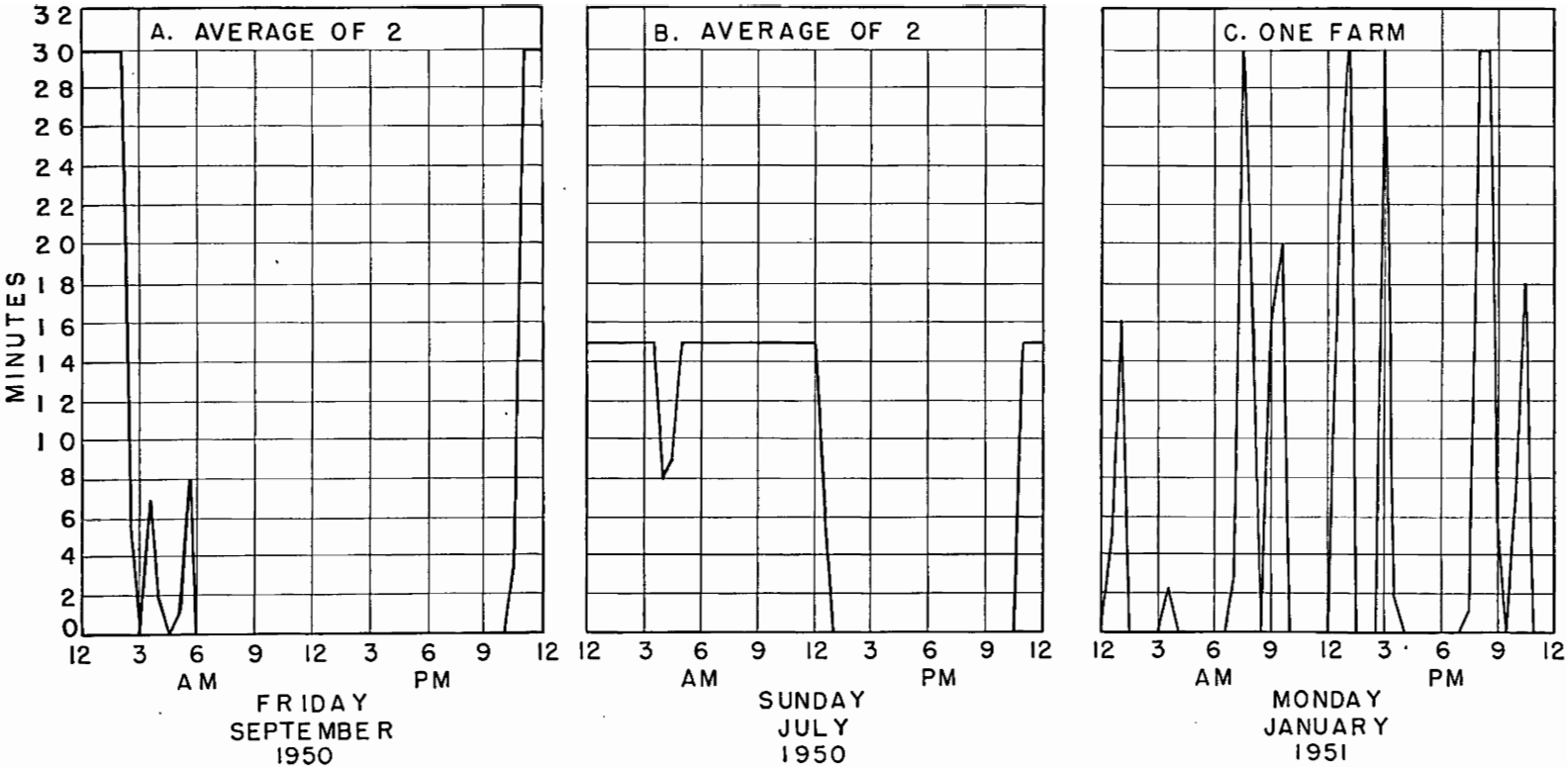



Fig. 21. Water heaters on off-peak control—minutes of use per half hour.

no washer; one had and used both an automatic and a nonautomatic washer; one discontinued a nonautomatic and purchased an automatic. One of the ironers was added during the

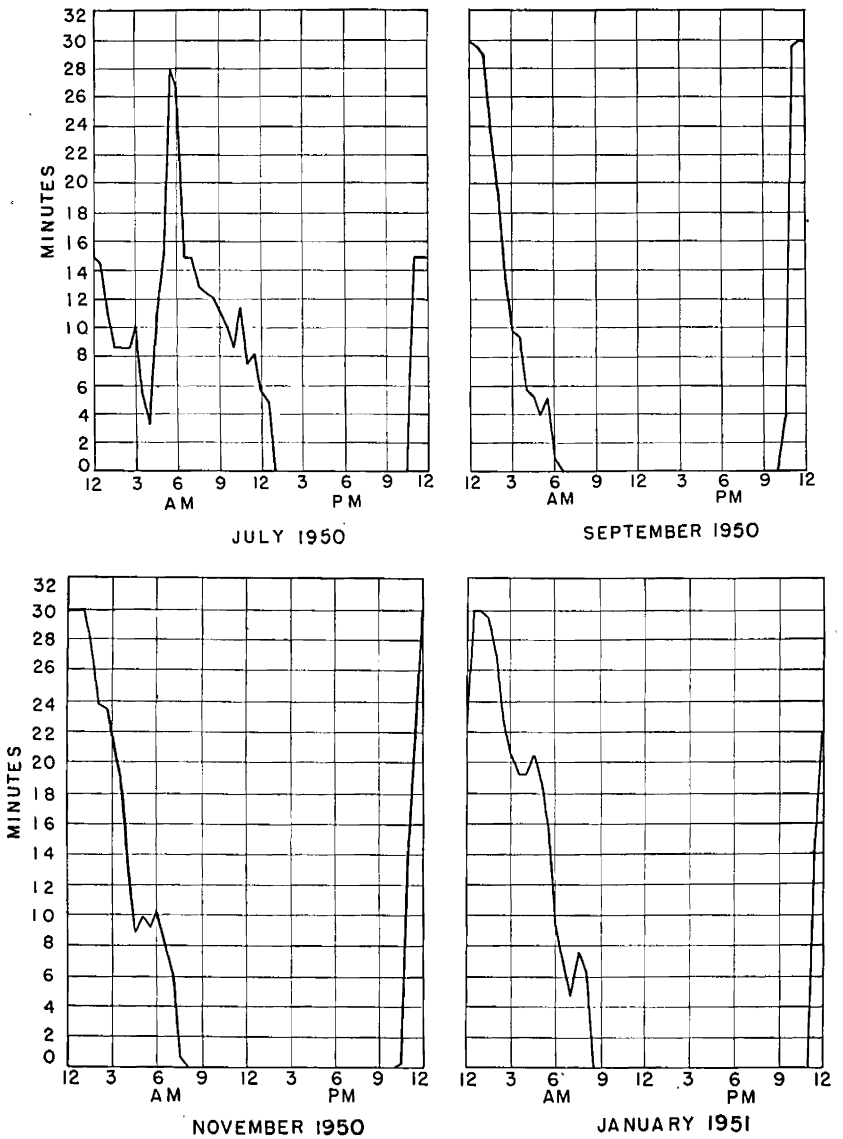



Fig. 22. Water heaters on off-peak control—minutes of use per half-hour, average of 2.

study. None of the cooperators owned an electric clothes dryer; ammeter records were obtained for one on another farm.

Since many laundry loads could not be tabulated from the metered records and since laundry equipment is used less frequently than many other major appliances and not necessarily with as great regularity, there are many gaps in the tabulated data for such equipment, and these have necessitated some arbitrary decisions with regard to making averages.

The following policy was used in computing the average weekly demands for laundry equipment: The average was based on the number of appliances of a given kind, as irons, for which legible records were available for the month. "Legible records," as used here, means that one could either identify the load of the appliance or be reasonably certain that it had not operated during the period metered. Therefore if there were 14 legible records for cooperators owning a certain appliance for a month, the average was based on 14 although fewer appliances had been used during the week metered. An exception was made in the case of a cooperator who owned both an automatic and a nonautomatic washer; when the nonautomatic washer was used, this cooperator was not included with the group owning automatic washers.

### WASHERS

The demand of automatic washers varies more than that of nonautomatic ones because of load variation at different times in the operation cycles. In addition, automatic washers, from the nature of their operation, may be used at times which would be inconvenient for washing by the conventional method. Since the automatic washer is a comparatively new appliance, there is a great deal of interest in the times at which the homemaker may use it and the effect of its use on the use-patterns of water heaters and other appliances. For these reasons automatic and nonautomatic washers are considered separately.

Table 11 shows average use of 3 automatic and 10 nonautomatic washers for September. For the weeks metered, Monday was the preferred day for using nonautomatic washers. Peak demand occurred from 9:30 to 10 a. m. Data from which the table was derived show that 6 of the 10 washers were in operation from 9:59 to 10:16 a. m. The next high demand was on Thursday from 10:24 to 10:51 a. m., when two washers were in use. Other demands were for only one washer. Demands of automatic washers were widely distributed. The demands of a day were in each case those of a single washer. Greatest demand of automatic washers occurred on Friday, Wednesday, Monday and Tuesday in descending order. Greater use occurred before noon than after noon for both types of washers.

TABLE 11. AVERAGE MINUTES OF USE PER HALF-HOUR OF AUTOMATIC AND NONAUTOMATIC WASHERS.

| Month and Day | HRS. A.M. 6:00 | 6:30 | 7:00 | 7:30 | 8:00 | 8:30 | 9:00 | 9:30 | 10:00 | 10:30 | 11:00 | HRS. A.M. 11:30 | HRS. P.M. 12:00 | 12:30 | 1:00 | 1:30 | 2:00 | 2:30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| September 1950 | | | | | | | | | | | | | | | | | | |
| Automatic—Average of 3 | | | | | | | | | | | | | | | | | | |
| Sunday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Monday | — | — | 9.7 | 5.3 | 7.3 | — | 7.8 | 3.7 | — | 2.7 | 5.7 | — | — | — | — | — | — | — |
| Tuesday | — | — | — | — | — | 0.3 | 9.0 | 5.0 | 6.0 | 7.3 | 5.3 | 0.3 | 6.3 | — | — | — | — | — |
| Wednesday | — | — | — | — | — | — | 7.7 | 8.0 | 9.7 | 2.7 | 9.0 | — | — | — | — | — | — | — |
| Thursday | — | — | 3.3 | 5.7 | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Friday | — | — | 8.3 | 7.7 | 7.7 | 10.0 | 8.3 | 7.7 | 8 0 | — | — | — | — | — | — | — | — | — |
| Saturday | — | — | — | — | — | — | — | — | 0.3 | 10.0 | 4.0 | — | — | — | — | — | — | — |
| Nonautomatic—Average of 10 | | | | | | | | | | | | | | | | | | |
| Sunday | — | — | — | — | — | — | 1.3 | 3.0 | 3.0 | 3.0 | 2.8 | — | — | — | — | — | — | — |
| Monday | — | — | 3.0 | 3.0 | 4.0 | 10.0 | 15.0 | 17.1 | 16.0 | 11.4 | 10.0 | 6.9 | 3.0 | 0.7 | — | — | — | — |
| Tuesday | — | — | — | — | — | — | — | — | — | — | — | 1.3 | 3.0 | 2.4 | — | — | — | — |
| Wednesday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Thursday | — | — | — | — | — | — | 1.7 | 3.0 | 3.6 | 4.2 | — | — | — | — | — | — | — | — |
| Friday | — | — | — | — | 0.3 | 3.0 | 3.0 | 1.7 | — | 2.3 | 3.0 | 3.0 | 3.0 | 1.0 | — | — | 1.7 | 2.5 |
| Saturday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Average of July, September and November 1950, and January 1951 | | | | | | | | | | | | | | | | | | |
| Automatic | | | | | | | | | | | | | | | | | | |
| Sunday | — | — | — | — | — | — | — | — | — | 1.9 | 0.4 | 1.9 | 0.1 | — | — | — | — | — |
| Monday | — | 2.5 | 5.1 | 2.7 | 3.7 | 3.0 | 8.5 | 6.9 | 4.5 | 5.8 | 6.6 | 2.7 | 2.5 | 1.6 | 1.8 | 1.5 | 1.1 | — |
| Tuesday | — | — | — | — | — | 0.3 | 4.6 | 3.8 | 2.3 | 3.8 | 3.3 | 0.1 | 1.6 | 1.9 | — | — | — | — |
| Wednesday | — | — | — | — | — | — | 1.9 | 2.0 | 2.4 | 0.7 | 2.3 | — | — | — | — | — | — | — |
| Thursday | — | — | 2.1 | 3.5 | 1.8 | 1.7 | 0.5 | 1.7 | — | — | — | — | — | — | — | — | — | 1.3 |
| Friday | — | 1.1 | 3.4 | 4.1 | 3.2 | 6.5 | 4.7 | 3.7 | 3.3 | 1.8 | — | 3.1 | 1.8 | — | 1.0 | 3.8 | 0.1 | — |
| Saturday | — | — | — | — | — | — | — | — | 0.1 | 2.5 | 1.0 | — | — | — | — | — | — | — |
| Nonautomatic | | | | | | | | | | | | | | | | | | |
| Sunday | — | — | — | — | — | — | 0.3 | 0.8 | 0.8 | 0.8 | 0.7 | — | — | — | — | — | — | — |
| Monday | — | — | 0.8 | 0.9 | 2.4 | 5.9 | 8.5 | 10.0 | 11.6 | 9.3 | 7.5 | 4.9 | 1.6 | 0.5 | — | — | — | — |
| Tuesday | — | — | — | 0.6 | 1.1 | 2.6 | 2.8 | 2.8 | 2.8 | 1.9 | 1.5 | 1.2 | 1.6 | 1.4 | 0.8 | 0.8 | 0.7 | — |
| Wednesday | — | — | — | — | 0.3 | 1.0 | 1.0 | 1.0 | 1.0 | 0.7 | — | — | — | — | — | — | — | — |
| Thursday | — | — | — | — | — | — | 0.4 | 0.8 | 1.3 | 2.6 | 1.7 | 1.6 | 0.3 | — | — | — | — | 0.8 |
| Friday | — | — | — | — | 0.7 | 1.6 | 1.6 | 1.3 | 0.8 | 1.0 | 0.8 | 0.8 | 0.8 | 0.3 | — | — | 1.3 | 1.6 |
| Saturday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |

TABLE 11.—CONTINUED

| MONTH AND DAY | HRS P.M. 3:00 | 3:30 | 4:00 | 4:30 | 5:00 | 5:30 | 6:00 | 6:30 | 7:00 | 7:30 | 8:00 | 8:30 | 9:00 | 9:30 | 10:00 | 10:30 | 11:00 | HRS. P.M. 11:30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| September 1950 | | | | | | | | | | | | | | | | | | |
| Automatic—Average of 3 | | | | | | | | | | | | | | | | | | |
| Sunday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Monday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Tuesday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Wednesday | — | 7.3 | 9.0 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Thursday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Friday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Saturday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Nonautomatic—Average of 10 | | | | | | | | | | | | | | | | | | |
| Sunday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Monday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Tuesday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Wednesday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Thursday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Friday | 3.0 | 0.2 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Saturday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Average of July, September and November 1950, and January 1951 | | | | | | | | | | | | | | | | | | |
| Automatic | | | | | | | | | | | | | | | | | | |
| Sunday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Monday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Tuesday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Wednesday | — | 1.8 | 2.3 | — | — | — | — | — | — | — | — | — | — | 0.6 | 2.9 | — | — | — |
| Thursday | 0.6 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Friday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Saturday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Nonautomatic | | | | | | | | | | | | | | | | | | |
| Sunday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Monday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Tuesday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Wednesday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Thursday | 1.0 | 0.5 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Friday | 0.9 | 0.1 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Saturday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |

Table 11 also shows average weekly demands of the 3 automatic and 10 nonautomatic washers by days for July, September and November, 1950, and January 1951. It is evident from this table that the average demands of both automatic and nonautomatic washers are greatest on Monday, that nonautomatic washers are not used on Saturday, and that automatic washers have a high demand on Friday during the periods metered. Demand of the nonautomatic washers is less diverse than that of the automatic washers.

The greatest use and highest demand of nonautomatic washers was always on Monday (table 11). The highest demand occurred between 9 and 10 a. m. in July and September, between 10 and 11 a. m. in November and between 10:30 a. m. and noon in January. The highest of these maximums occurred in November. These tabulations also show that for automatic washers the greatest use and highest peaks for July were on Friday and those for November and January on Monday.

Meter records for individual farms show that the use of the washer was accompanied by an increase in use of the water heater. When the water heater was controlled so that it was off from 7 a. m. to 11 p. m., the increased use was evidenced in longer operation during the night following the use of the washer.

### IRONING EQUIPMENT

Distinction between demands of irons and ironers was difficult, particularly if the ironer had only one heating element or if heating elements were not independently controlled. Some of the demands tabulated as those of irons may have actually been ironer demands. One cooperator did not use her ironer any time from early July until February although it was kept in a convenient place and there was no particular intention of discontinuing its use. This ironer was always considered in computing averages.

Demands of ironers were tabulated in average amperes per half-hour. The demand of an ironer is so variable that tabulation by minutes of operation would be a poor estimate of its demand. For purposes of comparison, the demands of irons were converted to average amperes per half-hour although they were tabulated as minutes of operation per half-hour.

Table 12 shows average weekly demand of 14 irons and 3 ironers for September. The highest demand of these irons occurred on Monday between 4 and 4:30 p. m. and greatest use on Tuesday. While greatest use of these irons occurred in the afternoon and evening, their use was well distributed over the hours of the day.

Data from which table 12 was obtained show that the highest

demand of irons was caused by the operation of three irons during the same half-hour of the week. Three irons were in operation within the same half-hour of the week 10 times for the periods metered in September.

As shown in table 12, ironers were used before noon on 2 days. Total use was about the same for the 2 days, but the ironer which was used on Friday created a higher peak than the one used on Wednesday.

Table 12 also shows average weekly demands by days of irons and ironers for the periods metered in July, September and November, 1950, and January 1951. The highest peaks of demand for irons in descending order came between 10 and 11 a. m. and between 8 and 8:30 p. m. on Wednesday, and between 4:30 and 5:30 p. m. and between 9 and 9:30 a. m. on Tuesday. Greatest use of irons by days in descending order for the 4 months occurred on Wednesday, Tuesday, Friday, Saturday, Thursday, Monday and Sunday. Periods of the day when irons were not used during the metering periods of these 4 months are 2:30 to 3 a. m., 5 to 5:30 a. m., and 11 p. m. to 1 a. m., a total of 6 half-hour periods.

Peak demands of ironers in descending order occurred from 2 to 2:30, 1 to 1:30 and 4 to 4:30 p. m. on Monday, and from 8:30 to 9 a. m. on Tuesday. The preferred days for using ironers were Tuesday, Monday, Friday, Wednesday and Thursday in the order mentioned. Ironer use was not observed on Saturday and Sunday.

The average demand of ironers for a given half-hour period is rather great as compared with that of an iron for several reasons: The wattage of an ironer is greater than that of an iron, the heating element of an ironer tends to be on for a greater portion of the time when in use than that of the iron, particularly at the first part of a period of use, and the motor operates all the time ironing is being done. However, since the operation of ironing equipment is rather diverse, the inclusion of fewer ironers than irons in the averages tends to emphasize the comparative demand of ironers. There were never more than 4 irons in operation on the same day of the week in a given month, yet there were 12, 14, 14 and 16 irons considered in the monthly averages while 5, 3, 5 and 6 ironers were considered.

Data from which the curves were derived show that for the periods metered in the 4 months the highest peak of use of irons occurred in July between 9 and 9:30 a. m. on Tuesday. The peak next in height occurred in November between 10:30 and 11 a. m. on Tuesday. Average use did not vary greatly from month to month. Use in September and July was about the same. Use was slightly less in November and January.

TABLE 12. AVERAGE AMPERE DEMAND BY HALF-HOUR PERIODS OF IRONS AND IRONERS.

| Month and Day | HRS. A.M. 12:00 | 12:30 | 1:00 | 1:30 | 2:00 | 2:30 | 3:00 | 3:30 | 4:00 | 4:30 | 5:00 | 5:30 | 6:00 | 6:30 | 7:00 | 7:30 | 8:00 | 8:30 | 9:00 | 9:30 | 10:00 | 10:30 | 11:00 | HRS. A.M. 11:30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| September 1950 | | | | | | | | | | | | | | | | | | | | | | | | |
| Ironers—Average of 3 | | | | | | | | | | | | | | | | | | | | | | | | |
| Sunday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Monday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Tuesday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Wednesday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 1.70 | 1.33 | — | — | 2.50 | 1.93 | — | — | — |
| Thursday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Friday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 2.77 | 3.00 | 1.10 | — |
| Saturday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Irons—Average of 14 | | | | | | | | | | | | | | | | | | | | | | | | |
| Sunday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 0.04 | 0.10 | 0.08 | 0.02 | — |
| Monday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Tuesday | — | — | 0.15 | 0.23 | 0.35 | — | 0.06 | 0.33 | 0.35 | 0.15 | — | — | — | — | — | — | — | — | — | — | — | 0.25 | 0.29 | 0.33 |
| Wednesday | — | — | — | — | — | — | — | — | — | — | — | — | 0.12 | — | — | 0.08 | — | 0.19 | — | — | — | — | — | — |
| Thursday | — | — | — | — | — | — | — | — | — | — | — | — | — | 0.10 | 0.23 | 0.17 | 0.17 | 0.10 | 0.21 | 0.23 | 0.11 | 0.27 | 0.44 | 0.06 |
| Friday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 0.12 | 0.21 | 0.15 | 0.48 | 0.06 | — | — |
| Saturday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 0.33 | 0.19 | — | — | — | — | — |
| Average of July, September and November 1950, and January 1951 | | | | | | | | | | | | | | | | | | | | | | | | |
| Ironers | | | | | | | | | | | | | | | | | | | | | | | | |
| Sunday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Monday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Tuesday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 0.33 | 0.60 | 0.75 | 0.60 | — | — | 0.60 | 0.55 | 0.20 |
| Wednesday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 0.18 | 0.15 | — | — | 0.28 | 0.20 | — | — | — |
| Thursday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Friday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 0.30 | 0.68 | 0.45 | 0.03 |
| Saturday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Irons | | | | | | | | | | | | | | | | | | | | | | | | |
| Sunday | — | — | — | — | — | — | — | — | — | — | — | 0.04 | 0.09 | 0.05 | — | — | — | — | 0.08 | 0.08 | 0.07 | 0.05 | 0.07 | 0.04 |
| Monday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 0.04 | 0.04 | 0.04 | 0.02 | 0.04 |
| Tuesday | — | — | 0.04 | 0.06 | 0.09 | — | 0.02 | 0.08 | 0.09 | 0.04 | — | — | 0.03 | — | — | 0.11 | 0.20 | 0.26 | 0.36 | 0.27 | 0.30 | 0.17 | 0.13 | 0.10 |
| Wednesday | — | — | — | — | — | — | — | — | — | — | — | — | 0.03 | 0.05 | 0.07 | 0.10 | 0.23 | 0.34 | 0.27 | 0.35 | 0.47 | 0.41 | 0.30 | 0.25 |
| Thursday | — | — | — | — | — | — | — | — | — | — | — | — | — | 0.03 | 0.06 | 0.04 | 0.04 | 0.09 | 0.15 | 0.09 | 0.08 | 0.14 | 0.13 | 0.06 |
| Friday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 0.03 | 0.13 | 0.15 | 0.30 | 0.04 | 0.02 | — |
| Saturay | 0.03 | 0.01 | — | — | — | — | — | — | — | — | — | — | — | — | 0.04 | 0.01 | 0.03 | 0.10 | 0.04 | — | 0.10 | 0.13 | 0.08 | 0.02 |

TABLE 12.—CONTINUED.

| MONTH AND DAY | HRS. P.M. 12:00 | 12:30 | 1:00 | 1:30 | 2:00 | 2:30 | 3:00 | 3:30 | 4:00 | 4:30 | 5:00 | 5:30 | 6:00 | 6:30 | 7:00 | 7:30 | 8:00 | 8:30 | 9:00 | 9:30 | 10:00 | 10:30 | 11:00 | HRS. P.M. 11:30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| September 1950 | | | | | | | | | | | | | | | | | | | | | | | | |
| Ironers—Average of 3 | | | | | | | | | | | | | | | | | | | | | | | | |
| Sunday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Monday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Tuesday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Wednesday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Thursday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Friday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Saturday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Irons—Average of 14 | | | | | | | | | | | | | | | | | | | | | | | | |
| Sunday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Monday | — | — | 0.12 | 0.23 | 0.19 | 0.31 | 0.12 | 0.25 | 0.60 | 0.35 | — | — | 0.15 | 0.23 | 0.12 | 0.27 | 0.21 | 0.25 | 0.11 | 0.02 | — | — | — | — |
| Tuesday | 0.35 | 0.02 | — | 0.15 | 0.44 | 0.50 | 0.56 | 0.50 | 0.42 | 0.52 | 0.58 | 0.46 | 0.48 | 0.29 | 0.13 | 0.33 | 0.52 | 0.23 | 0.04 | — | 0.19 | — | — | — |
| Wednesday | — | 0.06 | 0.13 | — | 0.19 | 0.52 | 0.13 | — | 0.13 | 0.15 | 0.13 | 0.33 | 0.33 | 0.29 | 0.31 | 0.44 | 0.48 | 0.44 | 0.46 | 0.13 | — | — | — | — |
| Thursday | — | — | — | — | — | 0.25 | 0.19 | 0.27 | 0.02 | — | — | — | — | 0.17 | — | — | — | 0.13 | 0.06 | — | — | — | — | — |
| Friday | 0.25 | 0.23 | 0.35 | 0.27 | 0.21 | 0.17 | 0.13 | — | — | 0.31 | 0.33 | 0.29 | 0.27 | 0.39 | 0.06 | — | — | — | — | — | — | — | — | — |
| Saturday | — | — | 0.04 | 0.42 | 0.13 | 0.31 | — | 0.10 | 0.21 | — | — | — | — | — | 0.15 | — | — | — | — | — | — | — | — | — |
| Average of July, September and November 1950, and January 1951 | | | | | | | | | | | | | | | | | | | | | | | | |
| Ironers | | | | | | | | | | | | | | | | | | | | | | | | |
| Sunday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Monday | — | — | 0.80 | 0.68 | 1.02 | 0.45 | — | 0.35 | 0.78 | 0.10 | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Tuesday | 0.20 | 0.30 | — | 0.45 | — | — | — | — | — | — | 0.23 | 0.33 | — | — | — | — | — | — | — | — | — | — | — | — |
| Wednesday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Thursday | — | — | — | 0.28 | 0.30 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Friday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Saturday | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Irons | | | | | | | | | | | | | | | | | | | | | | | | |
| Sunday | 0.06 | 0.05 | — | 0.06 | 0.07 | 0.07 | 0.04 | 0.05 | 0.06 | 0.05 | 0.05 | 0.02 | — | — | — | — | — | — | — | — | 0.07 | 0.03 | — | — |
| Monday | 0.02 | 0.02 | 0.05 | 0.06 | 0.05 | 0.07 | 0.05 | 0.13 | 0.23 | 0.13 | 0.13 | 0.11 | 0.10 | 0.13 | 0.08 | 0.07 | 0.15 | 0.08 | 0.07 | 0.08 | 0.07 | 0.04 | — | — |
| Tuesday | 0.09 | 0.01 | — | 0.19 | 0.25 | 0.30 | 0.24 | 0.25 | 0.21 | 0.37 | 0.39 | 0.27 | 0.26 | 0.24 | 0.12 | 0.11 | 0.13 | 0.06 | 0.01 | — | 0.04 | — | — | — |
| Wednesday | 0.07 | 0.04 | 0.13 | 0.13 | 0.15 | 0.29 | 0.14 | 0.13 | 0.21 | 0.23 | 0.23 | 0.11 | 0.11 | 0.09 | 0.16 | 0.25 | 0.39 | 0.33 | 0.19 | 0.03 | — | — | — | — |
| Thursday | — | — | 0.08 | 0.19 | 0.17 | 0.19 | 0.21 | 0.20 | 0.15 | 0.08 | — | — | — | 0.04 | 0.01 | 0.05 | 0.03 | 0.04 | 0.02 | — | — | — | — | — |
| Friday | 0.18 | 0.16 | 0.13 | 0.19 | 0.15 | 0.19 | 0.21 | 0.14 | 0.11 | 0.15 | 0.16 | 0.13 | 0.07 | 0.09 | 0.04 | 0.04 | 0.03 | 0.07 | 0.07 | 0.03 | — | — | — | — |
| Saturday | 0.05 | 0.07 | 0.03 | 0.11 | 0.05 | 0.16 | 0.03 | 0.17 | 0.18 | 0.17 | 0.11 | 0.04 | 0.23 | 0.23 | 0.14 | 0.11 | — | — | — | — | — | — | — | — |

There was a general tendency for use of irons to be greater after noon than before noon in all months.

### DRYERS

A clothes dryer was metered for 4 weeks between Feb. 26 and April 2, 1951. When this dryer was in operation, its demand was about 18 amperes at 230 volts. It operated every week on Monday for various periods between 7 and 10:30 a. m. The highest average use occurred between 8 and 8:30 a. m., a time of heavy electrical use for the 16 farms in this study. Average total use on Monday was about 70 minutes. The dryer was also used on one Thursday and one Sunday during the period it was metered. The homemaker said she used the dryer much less in summer than in winter.

### REFRIGERATORS AND FREEZERS

The demand of a refrigerator or a freezer is small and practically constant when operating, and a large number of peak demands for the whole farm included the operation of either or both.

Study of individual demands showed that there was a daily variation in the use of refrigerators. They operated a greater percentage of the time near mealtimes and in hot weather during the afternoon.

Tabulations were made for the length of the on and off portions of one cycle for each refrigerator and freezer between 3 and 4 a. m. for 4 days during each metering period. Percentages of operating time calculated from these values should give minimum values since this is usually the time of very low use for a day.

Using the above method the following values were obtained for minimum percentage operating time: refrigerators, July, 34 percent; September, 29; November, 24; January, 27; freezers, July, 29; September, 25; November, 16; January, 16.

## ADEQUACY OF ELECTRICAL SERVICE AND FARM WIRING

To evaluate electrical service and wiring, outages during the year were noted; voltages and voltage drops were measured; size and length of service and feeder wires and transformer sizes were ascertained; and a load-balance study was made.

### OUTAGES

Interruptions in service during the research period were few

and of short duration; however, several minor outages resulting from storms were recorded on the meter records.

## SERVICE TO THE METER

The average voltage at the meter of 16 farms, each on a different line, does not give a picture of existing voltage conditions; therefore the highest and lowest voltage at each farm for every hour of a day are presented in table 13. The values are one-half the voltage between the two 115-volt transformer circuits.

The voltage of 82 recorded on farm 16-1 between 7 and 8 a. m. was caused by the starting demand of a 3-hp 230-volt motor on a grain elevator. The voltage remained at this level for 2 minutes and then rose quickly to 210/105 volts.

Other records of the voltage at the meter of farm 5-4 show that voltages of more than 248/124 were frequent and at times were as high as 268/134. Farm 14-3 often had a voltage of 260/130 and on several occasions had a voltage as high as 266/133. These usually occurred at night.

Records also show that on several farms voltages of less than 210/105 were frequent. Farm 1-1 had voltages as low as 188/94 and farm 4-3 as low as 196/98. Periods of low voltage were most frequent during winter months at the time of system peaks. It was observed from meter records that voltages often dropped to a low level at the above times even though there was little or no load on the farm being metered.

Comparisons of ammeter and voltmeter records showed that the voltage to the meter fell when loads were added and rose when loads were removed. A wiring analyzer was used to check the extent of these variations. It was found that an average voltage drop of 2.97 percent occurred at the meter of each farm when the 1,000-watt resistance load in the analyzer was placed successively on each 115-volt circuit of the transformer. The percentage voltage drop for 1,000-watt loads in the service to each farm was calculated, and it was found that on the average 0.77 percent out of the 2.97 percent voltage drop to the meter was in the service. This left 2.20 percent voltage drop in the transformer and connections. These data are shown in table 14.

Three of the 16 farms had loads 100 percent above transformer rating for 15-minute periods or longer. Eight had loads 100 percent above transformer ratings for periods of 1 minute or longer. In one case the meter record showed that for a period of nearly an hour a 9.9-kva load was served by a 3-kva transformer. In this instance the voltage dropped to 192/96 at the meter. The time of this load was midnight Dec. 31, 1950.

TABLE 13. HOURLY MAXIMUM AND MINIMUM VOLTAGE FOR A THURSDAY, NOVEMBER 1950.

| Farm | A.M. 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | NOON 12 | P.M. 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1–1 | 122 | 122 | 122 | 120 | 119 | 118 | 116 | 116 | 119 | 121 | 119 | 118 | 121 | 120 | 122 | 122 | 121 | 115 | 114 | 117 | 120 | 121 | 120 | 121 |
| | 120 | 119 | 119 | 118 | 118 | 106 | 106 | 112 | 112 | 117 | 117 | 114 | 115 | 117 | 120 | 119 | 112 | 102 | 105 | 112 | 116 | 118 | 117 | 119 |
| 7–1 | 119 | 120 | 121 | 121 | 121 | 121 | 117 | 115 | 117 | 116 | 117 | 117 | 118 | 117 | 118 | 118 | 118 | 113 | 115 | 115 | 117 | 118 | 118 | 118 |
| | 116 | 118 | 118 | 119 | 119 | 117 | 114 | 111 | 110 | 109 | 108 | 113 | 115 | 114 | 115 | 116 | 112 | 111 | 108 | 114 | 114 | 115 | 113 | 115 |
| 8–1 | 127 | 128 | 127 | 127 | 127 | 125 | 125 | 123 | 125 | 124 | 124 | 123 | 124 | 125 | 125 | 123 | 122 | 120 | 123 | 123 | 123 | 126 | 127 | 127 |
| | 121 | 123 | 124 | 123 | 123 | 120 | 119 | 119 | 116 | 118 | 118 | 115 | 116 | 119 | 120 | 0 | 0 | 116 | 116 | 117 | 119 | 120 | 121 | 123 |
| 16–1 | 116 | 121 | 123 | 124 | 124 | 123 | 122 | 119 | 120 | 118 | 118 | 119 | 119 | 118 | 119 | 119 | 120 | 118 | 120 | 121 | 122 | 122 | 122 | 120 |
| | 113 | 115 | 120 | 120 | 119 | 120 | 114 | 82 | 106 | 116 | 104 | 110 | 114 | 106 | 112 | 113 | 108 | 105 | 116 | 117 | 118 | 120 | 120 | 114 |
| 3–2 | 121 | 120 | 121 | 122 | 122 | 122 | 126 | 123 | 121 | 123 | 122 | 123 | 121 | 120 | 120 | 120 | 119 | 119 | 119 | 118 | 119 | 120 | 120 | 118 |
| | 116 | 116 | 119 | 119 | 118 | 120 | 119 | 117 | 116 | 117 | 117 | 117 | 118 | 117 | 117 | 115 | 115 | 115 | 116 | 116 | 116 | 118 | 117 | 116 |
| 9–2 | 120 | 121 | 122 | 122 | 123 | 122 | 119 | 117 | 117 | 117 | 118 | 118 | 119 | 119 | 119 | 119 | 119 | 117 | 117 | 119 | 119 | 119 | 120 | 119 |
| | 118 | 120 | 121 | 121 | 121 | 118 | 116 | 109 | 115 | 115 | 116 | 113 | 117 | 116 | 117 | 117 | 115 | 113 | 110 | 116 | 117 | 118 | 115 | 117 |
| 11–2 | 118 | 118 | 119 | 119 | 119 | 119 | 119 | 117 | 113 | 112 | 114 | 115 | 117 | 116 | 117 | 116 | 115 | 115 | 116 | 113 | 113 | 115 | 116 | 116 |
| | 116 | 116 | 118 | 118 | 117 | 117 | 116 | 113 | 108 | 105 | 107 | 107 | 113 | 115 | 114 | 115 | 114 | 111 | 113 | 111 | 111 | 111 | 115 | 115 |
| 13–2 | 120 | 120 | 121 | 120 | 120 | 121 | 120 | 114 | 110 | 111 | 109 | 115 | 117 | 112 | 113 | 116 | 116 | 114 | 114 | 116 | 116 | 117 | 119 | 119 |
| | 119 | 118 | 120 | 120 | 119 | 119 | 116 | 106 | 108 | 108 | 107 | 109 | 114 | 110 | 110 | 111 | 113 | 111 | 112 | 111 | 115 | 115 | 117 | 118 |
| 2–3 | 115 | 114 | 116 | 117 | 117 | 115 | 114 | 114 | 114 | 117 | 117 | 116 | 116 | 119 | 116 | 114 | 114 | 111 | 111 | 111 | 113 | 115 | 115 | 115 |
| | 114 | 111 | 113 | 113 | 113 | 113 | 110 | 110 | 109 | 108 | 112 | 111 | 109 | 111 | 113 | 110 | 108 | 107 | 109 | 109 | 109 | 112 | 113 | 113 |
| 4–3 | 117 | 117 | 119 | 119 | 119 | 119 | 116 | 112 | 114 | 114 | 115 | 115 | 118 | 116 | 118 | 117 | 117 | 112 | 111 | 113 | 115 | 116 | 118 | 119 |
| | 115 | 116 | 115 | 116 | 117 | 114 | 110 | 109 | 109 | 112 | 111 | 110 | 114 | 107 | 115 | 115 | 109 | 104 | 106 | 109 | 111 | 112 | 115 | 117 |
| 12–4 | 120 | 120 | 121 | 122 | 122 | 122 | 118 | 118 | 117 | 117 | 117 | 118 | 118 | 118 | 118 | 119 | 118 | 115 | 116 | 119 | 119 | 119 | 119 | 119 |
| | 116 | 117 | 119 | 119 | 120 | 116 | 114 | 111 | 113 | 115 | 114 | 115 | 115 | 115 | 115 | 115 | 113 | 113 | 113 | 115 | 117 | 116 | 116 | 115 |
| 14–3 | 126 | 126 | 127 | 128 | 128 | 127 | 126 | 122 | 113 | 114 | 115 | 119 | 121 | 121 | 121 | 121 | 119 | 117 | 117 | 116 | 116 | 119 | 123 | 122 |
| | 122 | 124 | 124 | 123 | 122 | 123 | 121 | 111 | 109 | 107 | 110 | 112 | 114 | 117 | 117 | 116 | 115 | 113 | 113 | 111 | 111 | 111 | 118 | 119 |
| 15–3 | 111 | 113 | 115 | 120 | 121 | 121 | 119 | 118 | 119 | 118 | 119 | 118 | 119 | 119 | 120 | 119 | 117 | 113 | 116 | 117 | 119 | 119 | 119 | 119 |
| | 109 | 111 | 113 | 115 | 119 | 118 | 112 | 113 | 115 | 113 | 117 | 114 | 115 | 117 | 117 | 115 | 109 | 110 | 113 | 114 | 115 | 118 | 118 | 113 |
| 5–4 | 127 | 124 | 125 | 125 | 125 | 124 | 121 | 127 | 128 | 129 | 127 | 127 | 126 | 129 | 128 | 127 | 123 | 116 | 115 | 119 | 120 | 125 | 126 | 129 |
| | 117 | 116 | 122 | 122 | 114 | 113 | 116 | 118 | 122 | 124 | 120 | 123 | 121 | 120 | 124 | 121 | 115 | 109 | 109 | 114 | 113 | 119 | 123 | 124 |
| 6–4 | 116 | 116 | 116 | 115 | 116 | 116 | 113 | 116 | 118 | 119 | 118 | 118 | 117 | 119 | 119 | 119 | 117 | 111 | 114 | 115 | 115 | 116 | 117 | 117 |
| | 115 | 115 | 115 | 115 | 115 | 111 | 111 | 112 | 115 | 115 | 116 | 116 | 116 | 116 | 117 | 115 | 111 | 108 | 110 | 112 | 113 | 115 | 115 | 116 |
| 10–4 | 115 | 116 | 117 | 118 | 119 | 116 | 115 | 117 | 115 | 116 | 116 | 117 | 119 | 117 | 119 | 118 | 117 | 117 | 114 | 117 | 120 | 121 | 118 | 115 |
| | 114 | 115 | 116 | 117 | 116 | 111 | 113 | 115 | 113 | 113 | 114 | 114 | 115 | 115 | 115 | 117 | 115 | 111 | 111 | 112 | 117 | 117 | 114 | 113 |

TABLE 14. ADEQUACY OF SERVICE TO METER.

| Cooperator | Transformer size kva | Service wire | | Average percent voltage drop 1000-watt resistance load | | |
|---|---|---|---|---|---|---|
| | | Size | Length (one way) feet | Each circuit | Service wire* | Transformer, connections and other |
| Group I | | | | | | |
| 1–1 | 3 | 3–#6 | 70 | 2.25 | 0.42 | 1.83 |
| 7–1 | 3 | 3–#6 | 195 | 3.00 | 1.17 | 1.83 |
| 8–1 | 3 | 3–#6 | 170 | 3.00 | 1.02 | 1.98 |
| 16–1 | 3 | 3–#6 | 145 | 3.75 | 0.87 | 2.88 |
| Group II | | | | | | |
| 3–2 | 3 | 3–#8 | 60 | 3.25 | 0.57 | 2.68 |
| 9–2 | 3 | 3–#6 | 140 | 3.50 | 0.84 | 2.66 |
| 11–2 | 3 | 3–#6 | 265 | 3.00 | 1.58 | 1.42 |
| 13–2 | 3 | 3–#8 | 0† | 3.00 | 0 | 3.00 |
| Group III | | | | | | |
| 2–3 | 3 | 3–#6 | 0† | 1.50 | 0 | 1.50 |
| 4–3 | 7½ | 3–#4 | 140 | 2.00 | 0.53 | 1.47 |
| 12–4 | 3 | 3–#6 | 200 | 3.00 | 1.20 | 1.80 |
| 14–3 | 3 | 3–#6 | 100 | 2.25 | 0.60 | 1.65 |
| 15–3 | 3 | 3–#4 | 200 | 3.75 | 1.09 | 2.66 |
| Group IV | | | | | | |
| 5–4 | 3 | 3–#6 | 0† | 2.75 | 0 | 2.75 |
| 6–4 | 3 | 3–#6 | 195 | 3.00 | 1.17 | 1.83 |
| 10–4 | 3 | 3–#6 | 200 | 4.50 | 1.20 | 3.30 |
| Average | | | 135 | 2.97 | 0.77 | 2.20 |

*Calculated for a temperature of 76 degrees F.

†Transformer and meter on same pole. Meter loop neglected.

## WIRING FROM METER POLE TO EQUIPMENT

Farmers often added appliances with little regard to the adequacy of the farmstead wiring system. As a result there were several instances where wiring was too small for the distance and the load to be served. When farms were selected for the study, those with poor wiring were not included. In this respect, the wiring on the farms was not the poorest in this area.

Percent voltage drop for a 1,000-watt resistance load was measured at various buildings and electrical outlets on each farm. The greatest percent voltage drop observed on each farm, the size and length of wire from the meter to the load, the building and the appliances served are listed in table 15.

A load-balance study was made in April 1951. A recording voltmeter and a recording ammeter were installed on each 115-volt circuit of the transformer at the meter pole of each farm for a period of approximately 3 days. The voltage and the current on each transformer circuit at the time of maximum simultaneous difference in voltage between each of the transformer circuits and ground were tabulated from the records

TABLE 15. GREATEST PERCENT VOLTAGE DROP TO BUILDINGS ON EACH FARM.

| Cooperator | Feeder lengths, ft., one way | | | | | | Voltage no load | Voltage drop* percent | Location and usual load |
|---|---|---|---|---|---|---|---|---|---|
| | No. 6 | No. 8 | No. 10 | No. 12 | No. 14 | Total | | | |
| 1–1 | 25 | 190 | | | | 215 | 120 | 6½ | Brooder house, chick brooder and lights |
| 2–3 | 316 | 160 | | | | 476 | 119 | 7½ | Pole near hog house, cattle waterer |
| 3–2 | | 280 | | 110 | | 390 | 121 | 10 | Barn, 115-volt milker and lights |
| 4–3 | 60 | 175 | | | | 235 | 123 | 5½ | Brooder house, chick brooder and lights |
| 5–4 | 180 | | | 30 | | 210 | 122 | 7½ | Shop, shop tools and lights |
| 7–1 | 215 | 40 | | | | 255 | 118 | 5½ | Hog house, hog waterer and lights |
| 6–4 | 80 | | | 20 | 20 | 120 | 122 | 8 | Corn crib, 1-hole sheller and lights |
| 8–1 | 190 | | | | | 190 | 119 | 5 | Hog house, 8 heat lamps, hog waterers and lights |
| 9–2 | 90 | 85 | | | | 175 | 119 | 6 | Hen house, chicken waterer and lights |
| 10–4 | | 135 | | | | 135 | 119 | 5½ | Pump house, 115-volt pump jack |
| 11–2 | | 150 | | | | 150 | 120 | 5 | Corn crib, 230-volt 3-hp. motor on elevator |
| 12–4 | | 100 | 75 | 40 | | 215 | 120 | 6 | Barn, cattle waterer and lights |
| 13–2 | 195 | 100 | | | | 295 | 117 | 13 | Brooder house, lights |
| 14–3 | 315 | | | | | 315 | 122 | 6 | Hog house, 3 heat lamps, cattle waterer, lights |
| 15–3 | 30 | 130 | | | | 160 | 119 | 7½ | Barn, 230-volt milker, 1000-watt space heater, lights |
| 16–1 | | 100 | 95 | | | 195 | 122 | 7½ | Barn, 115-volt milker and lights |

*Thousand-watt resistance load.

TABLE 16. THE EFFECT OF UNBALANCED LOADS ON VOLTAGE AT THE METER, APRIL 1951.

| Cooperator | Maximum unbalance | | | | Difference current amperes | Difference volts |
|---|---|---|---|---|---|---|
| | Voltage | | Current | | | |
| | Circuit 1 | Circuit 2 | Circuit 1 | Circuit 2 | | |
| 1–1 | 88 | 100 | 14.0 | 6.0 | 8.0 | 12.0 |
| 2–3 | 113 | 118 | 25.6 | 4.0 | 21.6 | 5.0 |
| 3–2 | 113 | 119 | 20.0 | 0 | 20.0 | 6.0 |
| 4–3 | 99 | 112 | 43.0 | 7.5 | 35.5 | 13.0 |
| 5–4 | 102 | 108 | 25.6 | 0 | 25.6 | 6.0 |
| 6–4 | 110 | 117 | 12.0 | 0 | 12.0 | 7.0 |
| 7–1 | 105 | 112 | 19.2 | 6.0 | 13.2 | 7.0 |
| 8–1 | 110 | 120 | 16.0 | 0 | 16.0 | 10.0 |
| 9–2 | 110 | 114 | 16.8 | 4.0 | 12.8 | 4.0 |
| 10–4 | 111 | 116 | 18.8 | 0 | 18.8 | 5.0 |
| 11–2 | 106 | 112 | 12.5 | 2.5 | 10.0 | 6.0 |
| 12–4 | 110 | 120 | 18.4 | 0 | 18.4 | 10.0 |
| 13–2 | 116 | 119 | 11.4 | 0 | 11.4 | 3.0 |
| 14–3 | 112 | 114 | 17.6 | 0 | 17.6 | 2.0 |
| 15–3 | 110 | 118 | 21.2 | 0 | 21.2 | 8.0 |
| 16–1 | 107 | 114 | 14.7 | 0 | 14.7 | 7.0 |

collected. These data are presented in table 16. The records also show that seven of the farms had all 115-volt loads in the house on one circuit of the transformer. Five of these farms had 230-volt ranges or water heaters; the others had 230-volt service to the house but had all loads on one transformer circuit.

On the basis of these data it may be concluded that many of the farms in this area were wired without regard to balancing the loads on 230/115-volt services. Voltage conditions could be improved on many of these farms by balancing the loads between the 115-volt circuits.

## INCORRECT OPERATION OF EQUIPMENT

In the course of tabulating data from meter records, a few outstanding cases of improper operation of equipment were noted.

A ¾-hp motor was operated on a 115-volt circuit to drive a deep-well jet pump in one case. The pressure tank to which this pump was connected was water-logged for several months although the farmer was apparently unaware of it. Ammeter records showed that the pump started as many as 39 times in a 15-minute period. After this was brought to his attention, he corrected the water-logged condition and rewired the motor to a 230-volt circuit. He also replaced the switch which had been worn out by the frequent starting of the motor.

Another farmer used a ½-hp motor to operate a homemade ventilation system for his poultry house. A fan, salvaged from a farm tractor, was connected to the motor without proper regard to the speed at which the fan should run without overloading the motor. The motor was not protected against overloading and the power requirement of the fan was too great; consequently the motor burned out.

A homemade 25-gallon dairy water heater insulated with a 1-inch layer of corrugated cardboard and covered with asbestos paper consumed 397 of the 1,319 kilowatt-hours of electricity used on one farm from Nov. 6 to Dec. 11, 1950. Even when water from the heater was not used, it operated for short periods as many as 20 times an hour.

There are 13 automatic livestock waterers on the 16 farms in this sample. The small amount of water stored in the tanks of these devices reduces the amount to be kept from freezing. A study of stock-waterer temperatures was made in February 1951. Table 17 gives the outside temperature and the temperature of the water. It may be concluded from the data in this table that improper thermostat operation of electrically heated livestock waterers is common.

One farmer used an immersion stock-tank heater in an uninsulated 200-gallon tank. Shortly after he began using the heater, the thermostat failed. Upon inspection it was found that the inside of the thermostat was corroded and filled with water. The thermostat was cleaned and adjusted; but when the heater was put into service, the thermostat failed in such a way that the heater operated continuously. It was taken out of use because of excessive energy consumption.

TABLE 17. TEMPERATURES OF AUTOMATIC STOCK WATERERS, FEBRUARY 1951.

| Farm No. | Type of waterer | Water temp. °F. | Air temp. °F. |
|---|---|---|---|
| 2–3 | Hog | 75 | 27 |
| | Cattle | 47 | 27 |
| 8–1 | Hog, cattle combination—hog | 40 | 30 |
| | cattle | 60 | 30 |
| 14–3 | Hog (located in barn) | 47 | 31 |
| 3–2 | Hog | 46 | 31 |
| 12–3 | Hog | 46 | 31 |
| | Cattle | 48 | 31 |
| | Hog, cattle combination—hog | 46 | 31 |
| | cattle | 55 | 31 |

# APPENDIX

TABLE 18. EQUIPMENT OWNED, ADDED AND DISCONTINUED.

| List of equipment | Group I | | | | | Group II | | | | | Group III | | | | | | Group IV | | | | Grand total | Equipment added | Equipment discontinued |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1-1 | 7-1 | 8-1 | 16-1 | Total | 3-2 | 9-2 | 11-2 | 13-2 | Total | 2-3 | 4-3 | 12-4 | 14-3 | 15-3 | Total | 5-4 | 6-4 | 10-4 | Total | | | |
| Home Appliances | | | | | | | | | | | | | | | | | | | | | | | |
| Range | 1 | 1 | 1 | 1 | 4 | 1 | 1 | 1 | 1 | 4 | | | | | | | | | | | 8 | 1 | 1 |
| Water heater | 1 | 1 | 1 | 1 | 4 | | | | | | 1 | 1 | 1 | 1 | 1 | 5 | | | | | 9 | 1 | |
| Refrigerator | 1 | 1 | 1 | 1 | 4 | 1 | 1 | 1 | 1 | 4 | 1 | 1 | 1 | 1 | 1 | 5 | 1 | 1 | 1 | 3 | 16 | | |
| Freezer | 1 | 1 | 1 | | 3 | | | | 1 | 1 | | 1 | | 1 | 1 | 3 | 1 | | | 1 | 8 | 2 | |
| Toaster | 1 | 1 | 1 | 1 | 4 | 1 | 1 | 1 | 1 | 4 | 1 | 1 | 1 | 1 | 1 | 5 | 1 | 1 | 1 | 3 | 16 | 1 | 1 |
| Hot plate | | | | | | | | | | | | | | | 1 | 1 | | 1 | 1 | 2 | 3 | | |
| Waffle iron | 1 | | | 1 | 2 | | | 1 | 1 | 2 | | 1 | 1 | 1 | | 3 | 1 | 1 | 1 | 3 | 10 | | |
| Coffee maker | | | 1 | | 1 | 1 | | | | 1 | | 1 | | | | 1 | | 1 | | 1 | 4 | | |
| Roaster | | 1 | | | 1 | | | | | | | 1 | | | | 1 | | 1 | | 1 | 3 | | |
| Casserole | | | | | | | | | | | | | | | | | | | 1 | 1 | 1 | | |
| Egg cooker | | | | | | | | | | | | | 1 | | | 1 | | | | | 1 | | |
| Corn popper | | | | | | | | | | | 1 | | 1 | 1 | | 3 | | | | | 3 | | |
| Roaster grill | | | | | | | | | | | | 1 | | | | 1 | | | | | 1 | | |
| Deep fat fryer | | | | | | | | | | | | 1 | | | | 1 | | | | | 1 | | |
| Bottle warmer | | | | | | | | | | | | | | | | | | 1 | | 1 | 1 | | |
| Food mixer | 1 | 1 | 1 | 1 | 4 | 1 | | 1 | | 2 | | 1 | 1 | 1 | 1 | 4 | 1 | 1 | 1 | 3 | 13 | | |
| Dishwasher | | | 1 | | 1 | | | | | | | | | | | | | | | | 1 | | |
| Automatic washer | | | 1 | 1 | 2 | 1 | | | 1 | 2 | | 1 | | | | 1 | | | | | 5 | 1 | |
| Nonautomatic washer | 1 | 1 | 1 | | 3 | | 1 | 1 | | 2 | | | 1 | 1 | 1 | 3 | 1 | 1 | 1 | 3 | 11 | 1 | 2 |
| Iron | 1 | 1 | 1 | 1 | 4 | 1 | 2 | 1 | 1 | 5 | 1 | 1 | 1 | 1 | 2 | 6 | 1 | 2 | 1 | 4 | 19 | 1 | |
| Ironer | | | 1 | 1 | 2 | 1 | | | | 1 | | 1 | | 1 | 1 | 3 | 1 | | 1 | 2 | 8 | 1 | |
| Vacuum cleaner | 1 | 1 | 1 | 1 | 4 | 1 | 1 | 1 | 1 | 4 | 1 | 1 | 1 | 1 | 1 | 5 | 1 | 1 | 1 | 3 | 16 | | |
| Hand vacuum | | | | | | | | | | | | 1 | | | | 1 | | | | | 1 | | |
| Radio | 2 | 2 | 4 | 1 | 9 | 3 | 5 | 2 | 2 | 12 | 3 | 1 | 1 | 3 | 3 | 11 | 2 | 2 | 2 | 6 | 38 | 1 | |
| Radio and record player | 1 | | | | 1 | 1 | | | | 1 | | 1 | | | | 1 | | 1 | 1 | 2 | 5 | | |

TABLE 18.—CONTINUED.

| List of equipment | GROUP I | | | | | GROUP II | | | | | GROUP III | | | | | | GROUP IV | | | | Grand total | Equipment added | Equipment discontinued |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1-1 | 7-1 | 8-1 | 16-1 | Total | 3-2 | 9-2 | 11-2 | 13-2 | Total | 2-3 | 4-3 | 12-4 | 14-3 | 15-3 | Total | 5-4 | 6-4 | 10-4 | Total | | | |
| Record player | | | | | | | | | | | | | | | | | | 1 | | 1 | 1 | | |
| Television | | | 1 | 1 | 2 | 1 | | | | 1 | | 1 | | | | 1 | 1 | 1 | | 2 | 6 | 6 | |
| Movie projector | | | 1 | | 1 | | | | | | | 1 | | | 1 | 2 | | | | | 3 | | |
| Heat pad | | | | 1 | 1 | | 1 | | | 1 | | | | | 1 | 1 | 1 | | 1 | 2 | 5 | | |
| Electric blanket | | | | | | | | | | | | | | | 1 | 1 | | | 1 | 1 | 2 | | |
| Heat lamp | | | | | | | | | | | 1 | | | | | 1 | 1 | | | 1 | 2 | | |
| Vaporizer | | | | | | | | | | | | | 1 | | | 1 | | | | | 1 | | |
| House fan | | 1 | 1 | 1 | 3 | | 1 | | | 1 | 1 | 1 | | 1 | | 3 | 1 | | 1 | 2 | 9 | | |
| Hot air fan | | | | | | | 1 | | | 1 | | 1 | | 1 | | 2 | 1 | | 1 | 2 | 5 | | |
| Exhaust fan | | | | | | | | | | | | | | | 1 | 1 | | | | | 1 | | |
| Space heater | | | | | | 1 | 1 | | | 2 | | 2 | | | 1 | 3 | 1 | | | 1 | 6 | | |
| Coal stoker | | 1 | | | 1 | 1 | | | | 1 | | | | | | | | 1 | | 1 | 3 | | |
| Blower (furnace) | | 1 | 1 | 1 | 3 | | | | | | 1 | | 1 | | 1 | 3 | 1 | | | 1 | 7 | 1 | |
| Oil furnace | | | 1 | | 1 | | | | | | 1 | 1 | | | | 2 | 1 | | | 1 | 4 | | |
| Soft water pump | 1 | | | | 1 | 1 | | | | 1 | | | | | 1 | 1 | 1 | | | 1 | 4 | | 1 |
| Water pump | 1 | 1 | 1 | 1 | 4 | | | 2 | | 2 | 1 | 2 | 1 | 1 | 1 | 6 | 1 | 1 | | 2 | 14 | 1 | |
| Sump pump | | | 1 | | 1 | | | | | | | | | | | | | | | | 1 | | |
| Hair dryer | | | | | | 1 | | | | 1 | | | | | | | | | | | 1 | | |
| Toy motor | | | | | | | | | | | | | | | | | 1 | | | 1 | 1 | | |
| Electric train | | | | | | | | | | | | 1 | | | | 1 | | | | | 1 | | |
| Sewing machine | 1 | 1 | | 1 | 3 | | | | | | 1 | 1 | | 1 | | 3 | | 1 | | 1 | 7 | 1 | |
| Shaver | | | 1 | | 1 | 2 | | 1 | | 3 | | | | | | | 1 | | | 1 | 5 | | |
| Clippers | | | | | | | | | | | | | | | | | 1 | | | 1 | 1 | | |
| Farm Appliances | | | | | | | | | | | | | | | | | | | | | | | |
| Air compressor | 1 | 1 | 1 | 1 | 4 | 1 | | | 1 | 2 | 1 | 1 | | 1 | 1 | 4 | 1 | | | 1 | 11 | | |
| Drill | | 1 | | 1 | 2 | 1 | | | | 1 | | 1 | | 2 | | 3 | 3 | 1 | | 4 | 10 | | |
| Tool grinder | | | | 1 | 1 | | | | | | 1 | 1 | | 1 | | 3 | 1 | 1 | | 2 | 6 | | |
| Welder | | 1 | | 1 | 2 | 1 | | | | 1 | 1 | 1 | | 1 | | 3 | 1 | | | 1 | 7 | | |
| Battery charger | | | | | | 1 | | | 1 | 2 | | | | | | | | | | | 2 | | |

TABLE 18.—CONTINUED.

| List of equipment | GROUP I | | | | | GROUP II | | | | | GROUP III | | | | | | GROUP IV | | | | Grand total | Equipment added | Equipment discontinued |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1-1 | 7-1 | 8-1 | 16-1 | Total | 3-2 | 9-2 | 11-2 | 13-2 | Total | 2-3 | 4-3 | 12-4 | 14-3 | 15-3 | Total | 5-4 | 6-4 | 10-4 | Total | | | |
| Concrete mixer | | | | | | | | | | | | | | 1 | | 1 | | | | | 1 | | |
| Sander and polisher | 1 | | | | 1 | | | | | | | | | 1 | | 1 | | | | | 2 | | |
| Hack saw | | | | | | | | | | | | | | | | | 1 | | | 1 | 1 | | |
| Jig saw | | | | 1 | 1 | | | | | | | | | | | | 1 | | | 1 | 2 | 1 | |
| Circular saw | | | | | | 1 | | | | 1 | | 1 | | 1 | | 2 | 2 | | | 2 | 5 | | |
| Pig brooder lamps | | | 16 | 5 | 21 | 8 | 5 | | | 13 | | 5 | | 3 | 8 | 16 | | | | | 50 | | |
| Pig brooder, homemade | | | | | | | | | | | | 13 | | | | 13 | | | | | 13 | | |
| Brooder hover (chicks) | | | | | | 1 | | | | 1 | 1 | 1 | | 1 | 1 | 4 | 1 | | | 1 | 6 | 2 | |
| Heat lamp (for chicks) | | | | | | | | | | | | | | | | | | | 1 | 1 | 1 | | |
| Ventilating fan | | | | 1 | 1 | | | | | | | | | | | | | | | | 1 | | |
| Pump jack | 1 | | | | 1 | 1 | 1 | | | 2 | 1 | 2 | 1 | 1 | | 5 | | 2 | 1 | 3 | 11 | | |
| Water pump (pressure system) | | 2 | 1 | 1 | 4 | | | | | | | | | | 1 | 1 | | | | | 5 | | |
| Gas pump | | | | 1 | 1 | | | | | | | | | | | | | | | | 1 | | |
| Water heater (dairy) | | | | 1 | 1 | | | | | | 1 | 1 | | | 1 | 3 | | | | | 4 | | |
| 1/3 hp. portable motor | | | | 1 | 1 | 1 | | | | 1 | | 1 | | | | 1 | | | | | 3 | | |
| 1/2 hp. portable motor | | | | | | | | | | | 1 | 1 | | | | 2 | 1 | | | 1 | 3 | | |
| 3/4 hp. portable motor | | 1 | | | 1 | | | | | | | | | | | | | | | | 1 | | |
| 1/4 hp. portable motor | | | | 1 | 1 | | | | | | | 2 | | 1 | | 3 | | | | | 4 | | |
| Milking machine | | | | 1 | 1 | 1 | | | | 1 | 1 | 1 | | | 1 | 3 | 1 | 1 | | 2 | 7 | | |
| Cream separator | 1 | 1 | 1 | 1 | 4 | 1 | 1 | | 1 | 3 | 1 | 1 | | 1 | 1 | 4 | 1 | 1 | 1 | 3 | 14 | | 1 |
| Milk cooler | | | | | | | | | | | 1 | | | | | 1 | | 1 | | 1 | 2 | | |
| Conveyor | | | | | | | | | | | | | | 1 | | 1 | | | | | 1 | | |
| Wagon unloader (port.) | | | | | | | | | | | | | | | 1 | 1 | | | | | 1 | | |
| Hedge shears | | | | | | | | | | | 1 | | | | | 1 | | | | | 1 | | |
| Electric fencer | | | | 1 | 1 | | | | | | | | | 1 | | 1 | | | | | 2 | | |
| Grain elevator | 1 | 1 | 1 | 1 | 4 | | | 1 | | 1 | 1 | 2 | | 1 | | 4 | 1 | | | 1 | 10 | | |
| Corn sheller | | | | | | | | | | | | | | | | | | 1 | | 1 | 1 | | |
| Seed cleaner | | | | | | | | | | | | | | | | | | | 1 | 1 | 1 | | |
| Stock waterer | | 2 | 3 | | 5 | 1 | 1 | 1 | | 3 | 2 | | 2 | 2 | | 6 | | | | | 14 | 6 | 2 |
| Lamp, sterilizing | | | | | | | | | | | | 1 | | | 1 | 2 | | | | | 2 | | |
| Chicken waterer | | 2 | | | 2 | 1 | 1 | | | 2 | | | 1 | | | 1 | 1 | | | 1 | 6 | | |
| Buffer and grinder | | | | | | | | | | | | | | 1 | | 1 | | | | | 1 | | |